A TIMES OF INDIA PUBLICATION

JANUARY 1

SCIENCE TODAY

FOR EVERYM

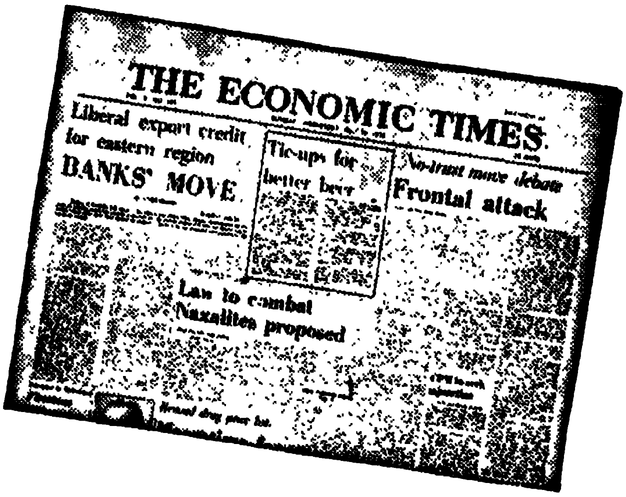
Your best Investment—
THE ECONOMIC TIMES
—devoted entirely to Commerce and Industry

The Economic Times, is the most important newspaper for today's businessmen, industrialists, entrepreneurs, investors, junior executives, research workers and students.

In a fast-changing world of far-reaching political, economic and scientific development you have to be well-informed to play your role intelligently and successfully.

Economic development and political decisions are interdependent. Thus, The Economic Times helps you to make the right decisions as its statistics are up to-date, its reports are authentic, comments timely and forecasts reliable.

You are in safe hands when you let The Economic Times be your guide and adviser.



A TIMES OF INDIA PUBLICATION

ABOUT THE AUTHORS

B. S. RAMAKRISHNA (*Acoustics of Music Halls*) is Professor of Acoustics in the Electrical Communication Engineering Department of the Indian Institute of Science, Bangalore. Dr. Ramakrishna took his PhD in electrical engineering from the Illinois Institute of Technology, Chicago, in 1949. Since then he has been teaching and doing research in acoustics and allied fields at the Indian Institute of Science.

RAMA (*The Ocean-floor is Spreading!*) is an associate professor with the Geophysics Research Group of Bombay's Tata Institute of Fundamental Research. Dr. Rama has worked on cosmic ray and elementary particle physics using nuclear emulsion techniques. His current field of interest is the application of cosmic ray products and other natural activities in geophysical studies.

Results of his radon measurements in the Arabian Sea first appeared in his article *The Monsoon Riddle* in SCIENCE TODAY of October 1966.

HRAND SAXENIAN (*To Select A Leader*) is a graduate both of MIT and Harvard Business School. Prior to forming his own firm of management consultants in 1961, he worked on applications of digital computers and operations research to military and industrial problems, taught management control at Harvard Business School, and was Vice-President and General Manager of the Econometric Institute in New York. He is currently working with, among other clients, the New England School Development Council and the Massachusetts Chiefs of Police Association on various aspects of communications, training and control.

● ●

G. A. BOUTRY (*Quantity vs Quality*) heads the Applied Physics Department for The Vacuum and Electronics Industries at the Conservatoire National des Arts et Metiers, Paris. He is the founder and President of the Electronics and Applied Physics Laboratories at Lineil-Brevannes, where he was Director of Research from 1948 to 1968, and the President of The Society of Civil Engineers of France.

Dr. Boutry was awarded the degree of Doctor of Science by the University of Paris in 1933. He has written four books on applied physics, and has published numerous scientific papers and articles on the history of science and technology.

AWARDS & APPOINTMENTS

Three Indian scientists have received **awards** for studies abroad under the Royal Society **and** Nuffield Foundation Bursaries.

Dr. K. M. Joshi of the Department of Chemistry, Institute of Science, Bombay, will do research in electrochemistry at the Department of Chemistry, University of Ottawa, Canada, for a year.

Mr. T. S. Radhakrishnan of the Solid State Physics Group, Tata Institute of Fundamental Research, Bombay, will study scientific and technological aspects of cryogenics at the Clarendon Laboratory, Oxford, England, for a year.

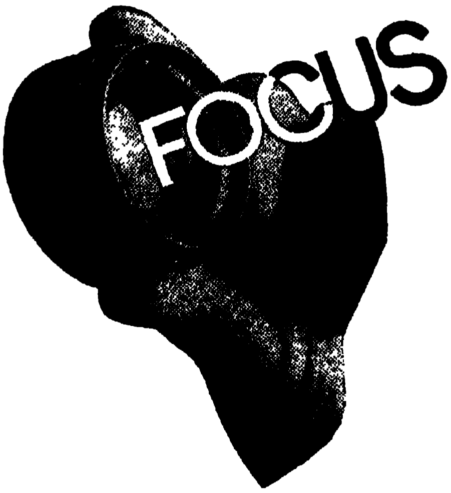
Dr. M. S. Ahmad, Department of Chemistry, Muslim University, Aligarh, will train in NMR and mass spectroscopy at the University College, Swansea, England, for 6 months.

Dr. N. M. Shah of the University Oceanographic Laboratory, Kerala, will study methods of estimating extracellular products of phytoplankton in sea water at Westfield College, London, under the Royal Society Commonwealth Bursaries scheme.

Prof. R. Narasimhan of the Computer Group, Tata Institute of Fundamental Research, has been awarded the Nehru Fellowship for 1970.

IN OUR FORTHCOMING ISSUES....

TIDAL WAVES
DESERT FARMING
MOONLANDING IN RETROSPECT
INFORMATION THEORY
INTERPLANETARY PARTICLES
PLANNING FOR WATER RESERVOIRS
BLOOD GROUPS



On Indian Science and Technology...

These columns are intended to pose from time to time such problems of scientific policy as do affect directly our present and future national development. The issues will be raised by men whose words can carry conviction. Our aim is to stimulate serious thinking and an informed discussion on a much wider scale than achieved by the past few officially organised conferences of scientists and technologists. Readers are invited to send their comments, preferably in about 750 words or less. Our first contributor to these columns is Prof. R. Narasimhan of the Computer Group at TIFR, who is also a keen student of science policy.

THERE has been much discussion lately about evolving a national science policy. A Science Policy Resolution (SPR) was adopted by the Government of India in 1958. COST (Committee on Science and Technology) organised a three-day conference in November, 1970, to assess to what extent the implementation of SPR has been successful, and to formulate guidelines for evolving a science policy for the country for the decade of the 70s. I could not be present at this conference, but I have gone through the background documents distributed to the participants, and I have talked to some who were able to participate in the conference. By and large, the general feeling seems to be that the conference did not accomplish anything very substantive. I think the principal reason for this was that the conference did not make a serious attempt to come to grips with the fundamentals of the problem. I would like to discuss here briefly what I think are some of the basic issues involved in evolving a science policy for the country.

To begin with, let us note that the question of implementing the SPR of 1958 does not really arise. For the SPR of 1958 is not an *action document.* It is merely a credo. It is a statement of faith. In effect, the SPR says: " Science is good. Science is glorious. Science and technology have much to contribute to national growth. The government has faith in science and technology. It pledges itself to do everything in its power to foster science and to make available its benefits to the people at large." Surely, this in itself does not constitute an action statement of *what is to be done.* It is merely an article of faith.

What seems to have gone wrong, in my view, is in following up this declaration of faith with an integrated scheme for action. Clearly, such an integrated scheme should have been the outcome of an effect to answer this question: "What are the things we want to accomplish to get the nation moving, and how can we *put science and technology to work* to accomplish these things? " We shall consider presently the methodological problems involved in trying to answer this question. But, first, note that what seems to have actually happened is that we have tried to interpret SPR as if it were an action document. It says, " Science must be grown. Science must be fostered. Scientists must have freedom ". Hence, a plethora of university science departments, advanced centres of research, national laboratories, and so on, have been set up, equipped and peopled. Growing science has been narrowly interpreted as growing research in science. Not as putting science to work.

It would be a fallacy to think that one cannot put science to work till science has been grown.

For, growing science and putting it to work are not two different activities. They are two aspects of the same activity. In the very process of putting science to work one necessarily grows it.

But, after having tried to grow science in more or less a vacuum for more than a decade, we have suddenly started wondering: "Have the returns from science been commensurate with the investments in science? Have the laboratories contributed? Have the scientists been pulling their weight?" Clearly, one cannot attempt to answer these questions without simultaneously answering the question "To what extent were laboratories and scientists *made to* contribute?" The background paper prepared by the COST Secretariat sums this up fairly:

> "The more clearly the objectives and time scale are set out to scientists and technologists working in the field, the more purposive will be their work for attaining them. In certain specific areas such as atomic energy and agricultural research, the clear guidance that has been given on objectives has led to significant achievements within fairly short periods of time. On the other hand, in cases where there were no clear objectives or directions, it has led to wastage of resources and even demoralisation among scientists working in the area."

Formulation of the objectives, the goals, for science and technology is the first fundamental problem. There are two aspects to this problem: evolving a methodology for formulating objectives and ensuring that the formulations are sufficiently well-defined and coherent so that they can lead to specifications for appropriate actions. The second fundamental problem is structuring a viable implementation machinery (the executive agencies) to translate these goals into actions and work out the necessary tactics for carrying out the actions. The third fundamental problem is monitoring and evaluating these actions on a continuous basis so that, at any given stage, one is reasonably certain one is progressing towards the objectives, and deadlines will be met. The central methodological problem in monitoring is being able to discover a set of indicators that describe the current stage of achievement and the current performance. These indicators must have the property that when malfunctioning occurs (i.e. in case of slippage, bottlenecks, etc) one can compute with reasonable precision what corrective actions are called for.

I suggest that only within the context of a planning + implementation + monitoring frame-work can one meaningfully discuss issues such as the following: Who should oversee science and technology? What should be the structure and functioning of executive agencies for putting science to work? How much autonomy should they have? How should their activities be coordinated? What roles should teaching institutions and R & D laboratories play in this process? How does one determine the resource allocations for R & D? Should the funding for R & D be done by the executive agencies or by some central body?

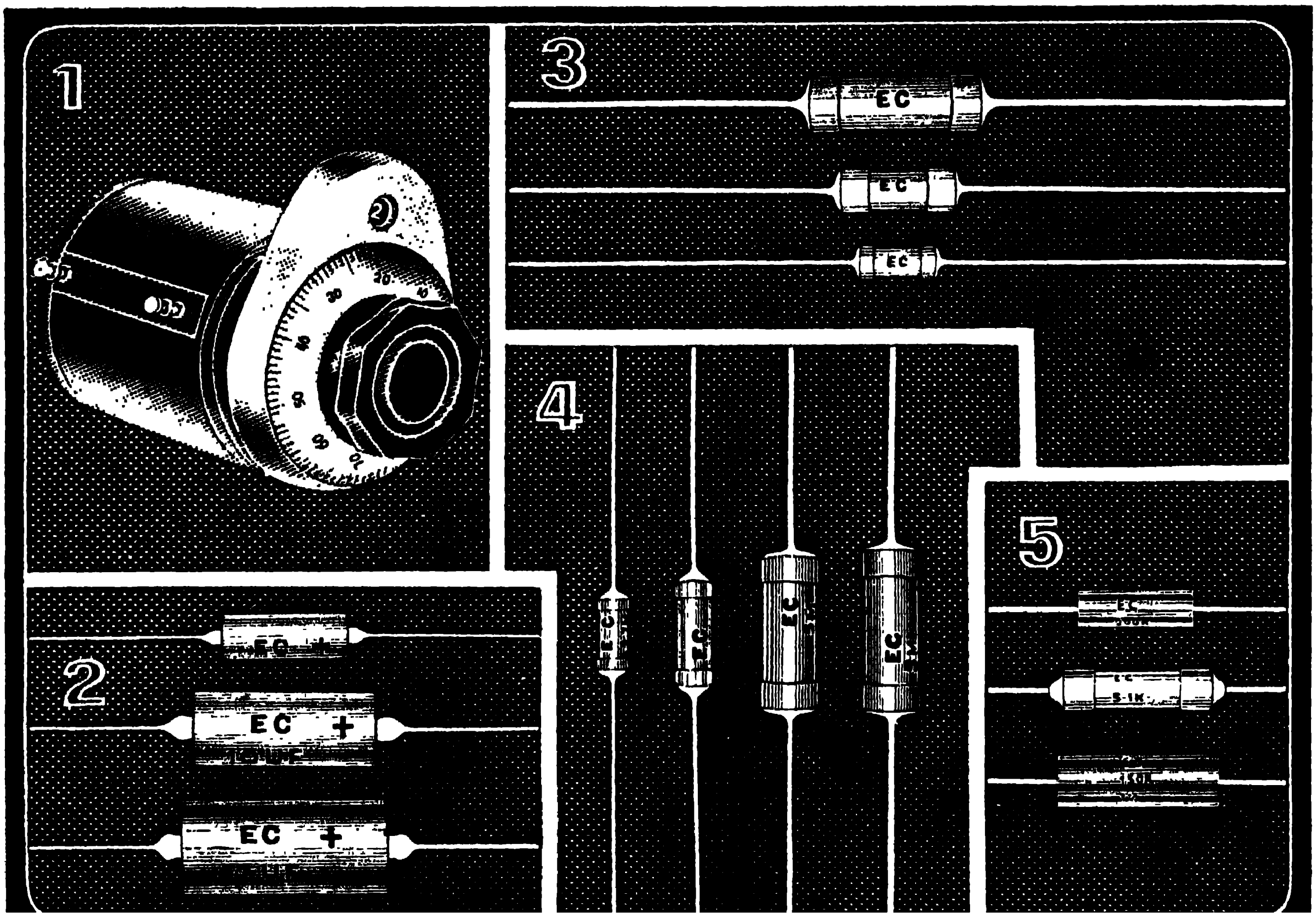
Defining the objectives

What is a viable methodology for defining the objectives for science and technology? I suggest that a rational approach is to determine a set of alternative technological profiles and study the feasibility and cost-effectiveness of each of these. In computing costs, of course, one would have to take into account social costs as well. Feasibility constraints must include not only economic factors but also political factors.

A technological profile, in effect, determines, for each aspect of national life, what kinds of technologies would be involved and at what levels. And then one would determine how much of this technological input would be purchased and how much would be locally grown. And one would also determine *in what forms* the technological inputs would be purchased. Notice that optimality considerations require that the technological profile must be worked out for the country as a whole — i.e. for all aspects of national life — in an integrated fashion. This problem is, of course, a profoundly difficult one. But that should not be an excuse for not attempting such an exercise. If not for *every* aspect of living, perhaps for very many aspects one could work out an integrated approximate profile.

Another way of describing a technological profile is to say that it determines a set of occupational categories and the distribution of the working population over these categories. It determines, for example, not only how many farmers there will be but also how many using these kinds of farming techniques (in terms of implements, chemicals, sources of water and power) and which ones of these inputs are to be purchased and which others are to be generated by other groups of people using these and these production techniques; and so on. And then there are more people who serve those described earlier, either personally or as part of an institution. While the current demands of living are met in this way using these techniques (and involving these purchases from outside the country), there are others who are preparing the ground (training, developing, experimenting, building) to transform the current technological profile into a new and

THE PASSIVE COMPONENTS THAT KEEP ELECTRONICS ACTIVE



Designed to meet international standards are these high precision resistors, tantalum capacitors and wire wound potentiometers. Manufactured by Electronics Corporation of India. Makers of quality electronic products.

1. Multiturn Wire Wound Potentiometer. Type 2.5 Y 10

10 Turn, 46 mm. Diameter. Threaded Bushing Mount. High Resolution and Linearity. Produced to meet DEF-5123 specifications. Dials with an accuracy of 1 part in 1000.

2. Solid Tantalum Capacitors.

High reliability and stability. Infinitely long shelf life. Wide temperature range -55°C to + 85°C. Withstands high accelerations. Low D.C. leakage current. Small size. Produced to meet DEF-5134 A-(U.K.)

3. High Stability Carbon Film Resistors. Type 'RC'

Low temperature coefficient. Low Voltage coefficient. Low noise level. Low shelf drift. Fully protected against severe tropical exposure and humidity.

4. Insulated High Megohm Resistors. Type 'RH'

Very low voltage coefficient. Wide range. 1 megohm to 10,000 megohms. Produced to meet MIL-R-14293-A of U.S.A and IS 2903 of India. Withstands 1500 volts insulation test. Low cost.

5. High Precision Moulded Metal Film Resistors. Type 'RM' 'MM'

High Frequency characteristics. Low temperature coefficient Very high stability. Low noise level. Replace wire wound resistors.

EC

ELECTRONICS CORPORATION OF INDIA LTD.,
R & C Division, Cherlapalli, Hyderabad-40

The people who put new ideas to work for the Nation.

mcm/h/ec-3

TABLE 1: IMPORTANCE OF R & D IN THE SALES DOLLAR, 1960

Industry	Amount (in cents)
1. Aircraft and Missiles	22·5
2. Communication Equipment & Electronic Components	12·9
3. Scientific & Mechanical Measuring Instruments	11·8
4. Other Electrical Equipment	9·4
5. Optical, Surgical, Photographic & other Instruments	6·5
6. Industrial Chemicals	5·3
7. Drugs & Medicines	4·4
8. Machinery	4·3
All Manufacturing (Average)	4·3
9. Motor Vehicles & other Transport Equipment	3·1
10. Nonindustrial Chemicals	2·2
11. Rubber Products	2·1
12. Fabricated Metal Products	1·5
13. Other Manufacturing Industries	1·4
14. Primary Metals	0·8
15. Paper & Allied Products	0·7
16. Textiles & Apparels	0·6
17. Lumber, Wood Products & Furniture	0·6
18. Food & Kindred Products	0·3

Source: "*N.S.F. R&D in Industry*, 1960", *Washington* 1963

more desirable one. The programming problem involved here is really a dynamic one. Not only static constraints, but dynamic ones have to be met. Our current practices must not only be mutually consistent so that current performance succeeds, but they must be consistent with our future goals, that is, with the new technological profile we have identified as being more desirable, and towards which we aim to move.

How much R & D and of what kind

A perspective formulation of technological profiles over a reasonable period of time (say, 10 or 15 years) will clearly identify objectives and time targets for educational and R&D activities. It will also determine lower and upper bounds for resource allocations.

It is worth noting here that it is precisely the preparatory work that is associated with efforts to change the technological profile that lends relevance to, and sustains at a high level, R&D and educational activities. In the post-war years, in the advanced Western countries, it is in the defence sector that this rate of change has been most rapid and significant. Consequently, the R&D allocations have also been high in this sector. In most of the remaining sectors, the activity levels have been determined, by and large, by current demands only. Consequently, the R&D allocations have also been low. This picture clearly emerges out of Table 1 which summarises the R&D efforts in the various industries in USA in 1960.

The first conclusion to be drawn from Table 1 is that there is a limit to the level of R&D in the industrial sector if the technological profile is kept static. In the limit, this level is likely to tend to zero. The second conclusion is that every country must work out its perspective of technological profiles to suit its own peculiar initial (historical) conditions and constraints. It would be a fallacy to think that there is something inevitable about the current technological profile of, say, the United States. The particular product mix prevailing there currently may be quite non-optimal for us. Consequently, the path through which Americans have reached this profile would also be non-optimal for us.

This shows that concepts like feasible production technologies, economy of scales, and so on, need not have any absolute validity. For example, it need not be true, in any absolute sense, that unless 1,00,000 automobiles are manufactured, automobile costs cannot be cut down. This need only be true for a particular technological profile. If the subsystems (e.g. body assemblies, engine assemblies, electrical assemblies, etc) that go into an automobile, and those that go into other systems (say, other transport vehicles) are pooled together and the technological profile suitably modified, manufacturing even 5,000 or 10,000 automobiles may become economical. Looked at this way, there may be no reason for separating defence and civilian production. By appropriate sharing of the subsystems, it should be possible to change over from one to the other with the maximum flexibility and rapidity. This analysis also shows why there is much less advantage in buying technology at the systems level rather than at the subsystems, components, or process level.

The 64,000-dollar question

Who should now work out the objectives for science and technology for India along the lines discussed above? Should COST do it, or the Planning Commission? Or, should, perhaps, the Indian National Academy of Science? Or, should the scientists at large? Or, should we, perhaps, give this as a contract to some American consultancy agency?

SCIENCE SHAPES LIFE

CHECKING GRAIN CONDITION

While storing grains, it is important to keep a continuous watch on their condition. A farmer usually relies on sight and smell to check grain condition. A British firm, Prolim, has come out with four systems for monitoring the temperature of stored grain.

One of them has a single-point meter and a lance, 2 or 4 metres long, to sense the temperature. The device works on batteries. In another system, the sensors are permanently located: temperature readings are obtained by plugging them to a meter. In the third system, the meter is also fixed permanently with several sensing points. Temperature reading for any point is obtained by using a selector switch. The fourth one is automated: it records temperatures from up to 6 points and also gives a print-out of the readings.

A SIPPER OR A GORGER?

Are you one of those polydipsiacs who drink too much water? Then you could be either an anxious person or simply hyperactive with, perhaps, a lust for life.

According to Dr. Cappon, a Toronto psychiatrist, there are two types of polydipsiacs — the frequent sippers and the gorgers. Those who belong to the first group are anxious people with a compulsive habit to moisten their mouths frequently. This relieves " primary anxiety ", says Dr. Cappon. The gorgers are people with " overworking appetites ", and they cannot restrain themselves from satisfying these appetites. They are also " hyperactive, nature-loving and sensuous ".

TEST FOR ALLERGY

Allergic reactions in some patients have been a problem in using penicillin injections. A research team from the New York University Medical School has now developed a reliable skin test that gives a clear answer for allergy in 15 minutes, it is claimed. Details of the test are not yet available.

CANCER PREVENTION

Biochemists at Princeton University, USA, are conducting experiments on mice to confirm the efficacy of a plant protein in preventing cancer growth. Earlier, they found that the protein, trypsinised Concanavalin A or Con A, checked cancer growth in cells removed from mice with induced cancer for six days — the period the cells lived outside the parent body.

NUCLEAR PROBE FOR SEA-BED MINERALS

A nuclear probe tipped with 1/3550 gram of the artificial radioactive element Californium-252 for exploring minerals on the sea-floor from either a submarine or a ship on the surface of the sea has been developed by scientists at the Battle North-West Laboratories. This has been done under the sponsorship of the US Atomic Energy Commission. The device will reveal the nature and quantities of about 20 to 30 elements, including gold and silver, on the ocean-floor in 3 to 5 minutes. This is said to be the first time that sea-bed minerals have been measured in their natural environment by means of a direct probing technique. The device is serviceable up to a depth of 300 metres. This permits its use on most of the continental shelves.

ELECTRONIC EARS

Electronic ears designed by Washington State University engineers can pick up inaudible sounds in the atmosphere — infrasonic waves produced when energy is released into the air by various sources. The information thus gained may help in atmospheric studies and the prediction of weather.

GROWTH HORMONE SYNTHESISED

Midgets may rise in stature and giants may be brought down to size by a promising breakthrough, the synthesis of the pituitary human growth hormone (HGH), by two US scientists, Dr. C. H. Li, University of California, and Dr. Philip R. Lee, Chancellor of University of California, San Francisco. Dr. Li was the first to isolate the hormone three years ago.

The pea-sized pituitary gland in the brain controls most of the human functions. One of the six hormones it secretes is the human growth hormone which controls the growth of the body; any fault in this control results in dwarfs or giants. The problem so far was that there wasn't enough of this hormone to conduct any extensive study on how exactly it works. The only source was pituitary glands from dead persons; a single gland gives about 5 mg of the hormone, enough only for three injections.

With a good supply of the hormone assured now, scientists may be able to eliminate dwarfism and giantism, study the growth process of the human body, including obesity, and probe cancer and the causes of several other diseases. According to the scientists, the hormone also aids resistance to infection and improves the performance of sex hormones.

AUTOMATION IN AGRICULTURE

Shortage of man-power in agriculture is not an immediate problem in India, but in developed countries, preparations are afoot to meet such a situation. Ultrasonically guided tractors, shakers for harvesting fruit and computers for milking cows are being tried at the National Institute of Agricultural Engineering in England, according to the Institute's annual report.

The report says that tractors, guided by an ultrasonic echo-ranging device, have been successfully used along artificial furrows, but on soil they raise some problems. Optical guiding devices are now being considered. Similarly, computers to calculate and feed the appropriate ration to each cow, to indicate the end of milking and record the yield and to calculate the feed ration for the next milking are being designed for the milking parlour.

PAKISTAN MAKES PAPER FROM JUTE WASTE

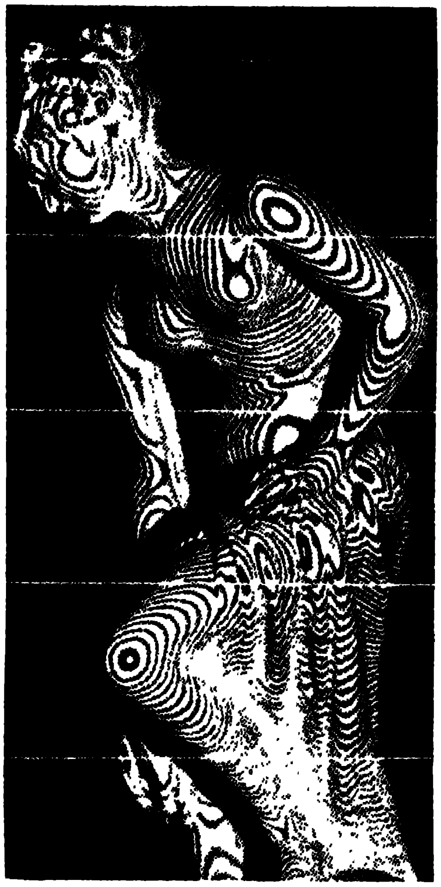
Most Asian countries, including India, face a paper shortage. Superior quality paper is made out of wood pulp. Jute stalks are also used as a minor constituent of the raw materials in some papers, particularly in non-white wrapping papers. Pakistan's Security Mills is now reported to have made paper from entirely indigenous raw material — jute waste.

Jute waste is a cheap resource, but it needs extensive processing in paper-making, which accounts for the cost. However, the cost does not work out to be high because of the cheapness of the raw material in this case. The Pakistani mill is reported to have developed paper comparable in quality to other wood-free papers. It is suggested that a good market in the Asian countries may make the paper a commercial success.

CONTOUR MAPS OF UNEVEN OBJECTS

A Japanese technique of outlining the contours of an uneven object may come in handy in engineering techniques such as measuring the deformation of an automobile tyre rotating at high speeds or studying the deformations of materials under stress. The technique, developed by a Japanese physicist, Dr. Hiroshi Takasaki of Shizuoka University, is based on the principle that two regular but different patterns overlap and interact to produce a third new pattern, like two transparent layers of cloth producing swirls. The phenomenon is called moire patterning.

The picture here shows a moire topography of a human body. To obtain this pattern, Dr. Takasaki placed a fine grating, consisting of parallel strands of fishing line coated with black spray paint, near the body. The graded shadows produced by the grating on the body are distorted and deformed by the body contours. Bold contour lines are thrown up on the body where the two lines in the two different patterns — the grating and the shadow lines — cross each other. The contours could be read knowing the distance between two successive lines.



In the picture, the depth between two contour lines is 2 mm, and the interval between the two horizontal white lines is 100 mm. Depth is indicated by the gap between contour lines.

INFRA-SOUND DAMAGES

Infra-sound, sound below the threshold level of hearing (i.e. with a frequency below 20 cycles per second) can cause symptoms similar to those of " drug trips," according to Dr. Richard Procumier of Lockheed. Such symptoms include disorientation, blurring of vision, headache, nausea and even physical damage to body tissues. Infra-sound may be part of the noise from aircraft, construction machinery, earthquakes, explosions or malfunctioning electric motors.

BRICKS FROM GARBAGE

A US company has developed a method of making bricks without using heat or kilns from residues left after burning garbage or any other inorganic waste material. Called the Tech process, the waste matter is dumped into a hopper and stirred after adding a little water, some Portland cement and a combination of chemicals. The mixture is then pressed into bricks, which need only a day's drying, in a mechanical press.

WATERPROOFING PROCESS

Waterproof shoes and leather garments are expected to be in the market within another five years. This is because of the discovery of a method of waterproofing leather by Dr. Stanley Briggs, a lecturer at Leeds University, England.

A PEEP INTO THE COMPUTER INDUSTRY

From the time the first generation computers were introduced in 1951–52 to now when the fourth generation ones are getting underway, the computer industry has come a long way — both in numbers and technology. Between the second (1958–60) and the third (1963–65) generations of computers, their number rose four-fold. From the third to the fourth, the increase was ten-fold. And when the fifth generation computers get underway by about 1975, it is estimated that there will be 2,00,000 computers in the world and about 5,00,000 by the end of the 70s, according to a British survey. A computer then may be a household gadget.

Computer technology and materials, too, have changed with each generation. The first generation used vacuum tubes, the second used transistors and the third generation which grew up during the mid-60s had integrated transistor circuits. The third generation computers had also special orientation towards communications with remote terminals, mass storage and large internal memories. Though these succeeded in many respects, certain of their failures such as low efficiency and large memory requirements have led to greater improvements. Thus the fourth generation uses mediumscale integrated circuits, semi-conductor memory cores in place of magnetic cores, special modules and processors for specific functions and a number of remote terminals.

What will the future fifth generation computers be like? Experts predict that they will have only three electronic components, one each for the processor, memory and input-output, and 100 times more efficiency. Future semi-conductor memories will have one crore bits per memory instead of the present 1,00,000. And within this decade, portable computers will be in use; they can be connected to telephone and electric points or work on batteries. The telephone, it is predicted, will be the most widely used terminal of the 70s, thus allowing remote-feeding. With the remote terminal and a packaged programme, computers can then be used conversationally. Computer systems which use languages meant for non-professionals are already being designed, and in another decade, computers may aid ordinary men in doing their daily chores.

The waterproof leather can be dyed in any colour and costs only a few paise more per square foot than leather tanned by normal processes. The new process involves the chemical bonding of fibres within the leather in a single step during tanning. The process uses a long flexible chromium complex of high molecular weight. The garments withstand repeated dry cleaning.

NOBLE METAL RECOVERY

A new process developed by Israel's Technion in Haifa enables up to 100 per cent recovery of gold or other precious metals dissolved in acid solutions using an ion-exchange resin. The acid solution is passed through the ion-exchange column with the resin. Noble metals such as gold, platinum and its analogues are retained by the resin and are recovered by roasting or using a chemical agent. The resin is a styrenedivinylbenzene copolymer with a resonating amino group.

The resin is available with Ayalon Water Conditioning Company, Haifa, Israel, and has been patented in the US, Canada and Britain.

LIP-PRINTS GIVE AWAY IDENTITY

When the Metropolitan Police Department of Tokyo received a letter threatening to blow up their headquarters, they rounded up two suspects and called in two lip-print experts also; the envelope had two lip-prints on it. But the experts found that the lip-prints of the suspects were different from those on the envelope.

Lip-prints can give away the identity of criminals; no two lip-prints are exactly similar, not even those of twins, according to the two Japanese scientists, Kazuo Sazuki and Yasuo Tsuchihashi, and this fact may help in identifying criminals.

TV SYSTEM HELPS DOCTORS

A television screen that shows three sets of pictures simultaneously has been developed by research workers of Leeds University, England. The system is now being used by doctors to watch the progress of instruments such as a catheter inside complicated human blood vessels.

The three-in-one instrument shows, superimposed on one screen, an X-ray picture of the patient, a record of his heart action and measurements picked up by the probe inserted in the body. According to doctors, the system should make the insertion of probes into the heart and kidneys through blood vessels much easier.

The system has already been used to find the best position in the heart for the electrodes of a pace-setter or an electrical heart stimulator and to pinpoint a malignant tumour. The prototype has cost less than Rs. 36,000 to develop.

NEW POWER SOURCE

Geothermal development can provide an important source of power when there is much outcry against environmental pollution. But efforts in this direction have been stalled by legal hurdles, land law, tax law, etc except in Italy and Japan where they are being vigorously pursued. And now, if the proposal gets Presidential assent, the US may also go in for geothermal power.

The sources are the hot spots inside the Earth. Some of these spots, close enough to the surface, can be made to release steam and drive a turbine to generate electricity. In a 80,000-kW power station set up on private land in California, wells have been drilled into underground sources of water in natural hot rock formations at a depth of about 2,500 metres. The hot water, rising under declining pressure, turns into steam and is led to generating turbines.

Another company will use natural hot water from thermal formations in a heat-exchange device to raise the temperature of liquid isobutane which in turn will drive the turbine. This will prevent the corrosion of the pipeline by contact with the chemical-containing hot water. Meanwhile, the US Atomic Energy Commission, in collaboration with some organisations, is studying the feasibility of nuclear explosions in hot rock formations to create a chimney of hot broken rock. Water could be pumped through this chimney to create steam.

CONTROL FOR FAST TRAINS

In the new trains running between New York and Washington in the US, speed acceleration and braking are automatically controlled. Of course, the train has a driver, but he is there only to select the speed. Signals for speed control come from sensors mounted on the gears of a combined motor and gear unit driving each axle. The train can run at a speed of about 255 kmph.

The rate of acceleration and deceleration and the slipping or locking of the wheels are checked by signals from various sensors. Power supply is cut for maximum efficiency if the wheels slip during acceleration because of track conditions. Locking under braking leads to a reduction in the power being supplied to the dynamic braking system. As the speed is reduced under braking, the automatic control cuts in the air braking system.

PUREST SUBSTANCE

Ultra-pure germanium, developed by General Electric's Research Centre, has been claimed to be the purest substance on the Earth. It has less than one atom of impurity per trillion—that is like having a grain of table salt in a freight car full of sugar. The substance (picture above) was developed in an attempt to make more effective devices for detecting high-energy radiations like X-rays, gamma rays, etc.

BACTERIA 'LICK UP OIL

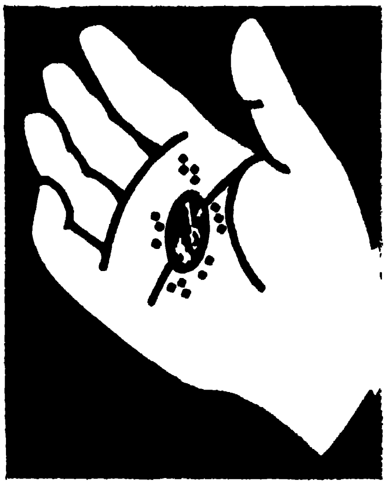
Oil tankers use salt water to clean their tanks in the sea. The resulting salt water-oil mixture is usually used as ballast and then, in some cases after partial recovery of oil on shore, is pumped into the sea. This causes marine pollution.

Various mechanical processes are being tried or developed to fight marine oil pollution (see Science Today, October 1970). But Russian scientists are now using biological methods to remove oil traces. They cultured marine bacteria in large settling tanks containing the ballast mixture. To speed up oxidation, they introduced certain kinds of green seaweeds, which can live in the oil-salt water mixture, into the tanks. Encouraged by the success, the Soviet scientists now plan to set up a complete eco-system including bacteria, plants and animals (molluscs) in the settling tank. Currently, their experiments are directed towards finding out the right conditions for self-sustenance of such a system.

ITCHY PALMS ARE REAL

The case of an army veteran whose palms literally itched for money is described by a Brooklyn, USA, allergist. After returning from Viet Nam where he had been in charge of television programmes broadcast from Saigon, the patient could obtain only a low-paying TV job. He suddenly developed an urticaria, first on his palms and later on his arms, chest and back.

No amount of medication or dietary treatment was helpful. His condition improved only when he obtained a better-paying job. Dr. Maury D. Sanger, the allergist, says the patient is typical of the puzzling type who does not fit the conventional antigen-antibody reaction.



Another example of a target symptom cited by Dr. Sanger was the man who developed chronic dermatitis on the third finger of his right hand where he wore a gold signet ring given to him by his wife after his return from Army service in Paris. It turned out that he had been unfaithful during his stay there. After he aired his guilt feelings and was reassured by the physician, the dermatitis vanished.

ARE YOU GETTING THE MOST OR SIMPLY PAYING THE MOST

COSMIC

Solid State

CO-40 DELUXE

An all-transistor integrated amplifier, designed for high quality stereophonic or monophonic reproduction, the latest in the range, CO-40 offers all the advantages expected from solid-state circuitry... Instant warmup... Low current consumption... Cool Operation... Low Distortion and Noise... Good Transient Response... Wider Frequency Response at full power... and Transformerless Output Circuit.

TECHNICAL SPECIFICATIONS FOR COSMIC SOLID-STATE STEREOMASTER HI-FI AMPLIFIER MODEL CO-40 DELUXE

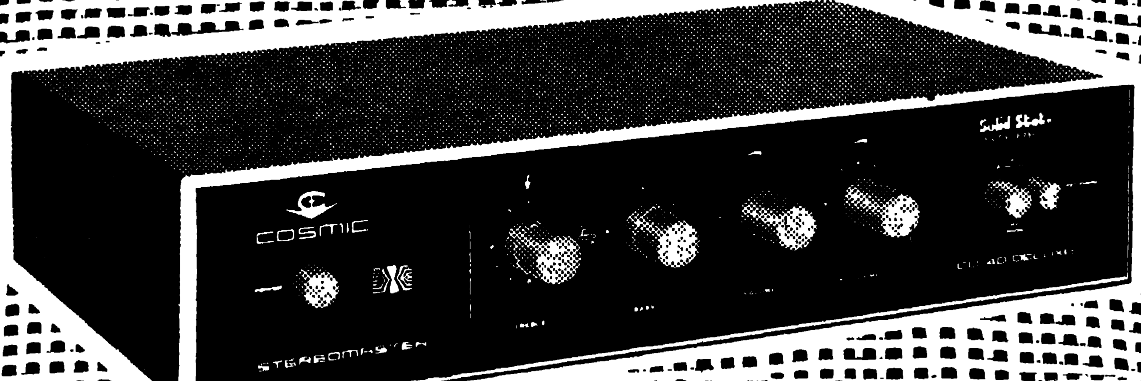
*Power output per channel. 20 watts at 4 Ohms Music power 10 watts RMS per channel * Frequency Response 20 to 20,000 Hz± 2dB *Harmonic Distortion (at rated output) Less than 0.5 at 1 kHz

MANUFACTURED IN INDIA BY:

COSMIC RADIO

3/A SHANTINAGAR, VAKOLA, SANTACRUZ (EAST),
BOMBAY-55 ☐ PHONE: 535315, 535316.
☐ GRAM : SOLIDSTATE

Ad CR-15



CO-40 DELUXE

Acoustics of Music Halls

B. S. Ramakrishna

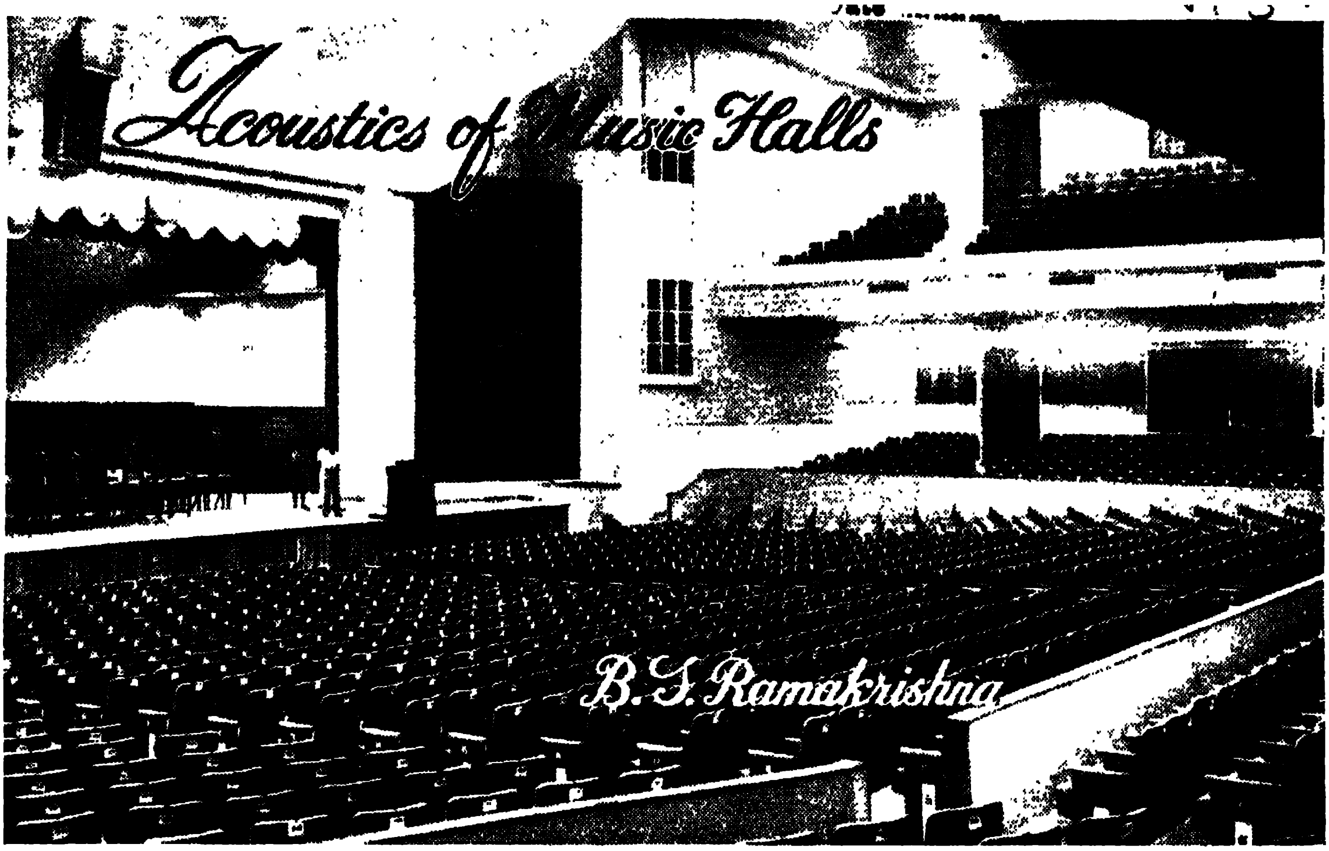


Fig. 1 A general view of the Centenary Auditorium of Madras University showing the stage, orchestra well and side balconies

BLACK or white, good or bad, sweet or sour — this dichotomisation of human experience is part of our linguistic tradition. It is the same habit of thought that leads us to categorise knowledge into arts and sciences. It is not surprising therefore that we still debate whether acoustics of music halls is a branch of science or of arts. In real life, problems are never posed so neatly that they can be handled by the tools of a particular discipline. Music, architecture, town-planning, geriatrics — almost any discipline having a sociological significance — cut across the traditional boundaries between arts and sciences. We must learn to take a global view of the problem before we can find satisfactory solutions.

Concert hall acoustics has been at the cross-roads of music, architecture and physics for many years. New streams like electronics and communications have come to pass through it, but only a few of the practitioners of any discipline ever remain there long enough to make their contributions to the building of this edifice. Unfortunately, not all of them even speak the same language. The musician talks of the liveness and intimacy of a hall and the warmth and fullness of tone, while the physicist talks of the resonance and reverberation of a hall and the frequency and intensity of a tone. The architect sees the spaces and forms and their functions and harmony. Small wonder that progress in the scientific design of music halls has been slow and success-rates rather low even to this day. But there is no need for the kind of despair which plagued Charles Garnier, the architect who designed the Opera House of Paris a hundred years ago. All that he could learn after touring all of Europe was that good acoustics might come from the hall being long or wide, high or low, round or square, hot or cold, empty or crowded, dark or illuminated or by lining the inside with wood or stone or by having snow and trees inside. Today we have a considerable body of scientific knowledge, though scattered among many disciplines, and the aid of a sophisticated technology of electronics and computers. We can augment the natural sound and control its distribution in ways that can be beneficial. But success will not come automatically. It will need, above all, the cooperation of a large team of specialists — the musician, the architect, the acoustician, not to speak of the illumination engineers and ventilation experts. It is the architect, however, who must coordinate the expertise of these specialists like the surgeon coordinates the work of the pathologist, the anaesthetist, the nurse and other members of a surgical team.

Nature of the problem

The acoustical design of a music hall is basically a problem in communication. In communication through speech, the naturalness of speech and its intelligibility are adequate criteria to judge how well the task is achieved. In the case of music, however, we are concerned with less tangible measures like tonal clarity and blend, reverberance and resonance — in short with the question of how well the hall helps to transmit to the audience the emotional content that the composer and the musician want to convey. In the final analysis, these are subjective experiences from physical (sound) stimuli. The problem is to relate in a quantitative manner the parameters of the subjective responses to those of the physical stimuli that can be measured. Most of the studies in psychoacoustics deal with the responses produced by pure tones or some other simple patterns of sound and cannot, therefore, be applied directly. We have to resort to analysing our total experience in music halls in terms of such physical measurements as we can make in them.

The first definitive steps in this direction were taken toward the close of the last century by Sabine. He studied the growth and decay of sound energy in rooms. Common experience tells us that in a large empty room with hard walls, any sound made inside is prolonged for a few seconds after the source itself has stopped to produce the sound. The persistence of sound is caused by the multiple reflections of sound waves from the walls, floor and ceiling until they are absorbed, and is known as reverberation. Reverberation must be distinguished from echo which is a delayed reproduction of the same sound due to a single reflection. In reverberation, the echoes are so many and come so fast on each other that the ear can no longer resolve them. It is customary to define the reverberation time (RT) of a hall as the time taken for the sound intensity to fall down to a millionth of the value when the source is stopped. It is given by Sabine's celebrated formula $T = KV/a$ where V is the volume of the hall, a is the total absorption and K is a constant equal to 0·049 when British units are employed and to 0·161 when metric units are used. The reverberation time of a hall thus depends on all the sound absorbing materials such as draperies, upholstered seats, wood panelling, acoustic tiles and plaster and, most important of all, the audience present in the hall. Most materials absorb sounds of different frequencies differently, and, therefore, the reverberation time of a hall also varies in general with frequency. Curtains, carpets and most porous materials fixed close to a rigid surface absorb up to 50 per cent or more of the sound energy in the high frequency range, i.e. frequencies above 2,000 Hz. Wood panelling on the walls, galleries, etc mainly absorb low frequency sounds below 200 Hz. Heavily upholstered seats, audiences, acoustical tiles generally absorb to a large extent a wide range of frequencies, from 100 Hz to 6,000 Hz or more, beyond which absorption by the air in the room becomes the dominant factor.

Thus the correct reverberation time for a hall depends on several factors—the size of the hall, the type of music, the frequency. For most music halls, it lies between 1 and 2 seconds,

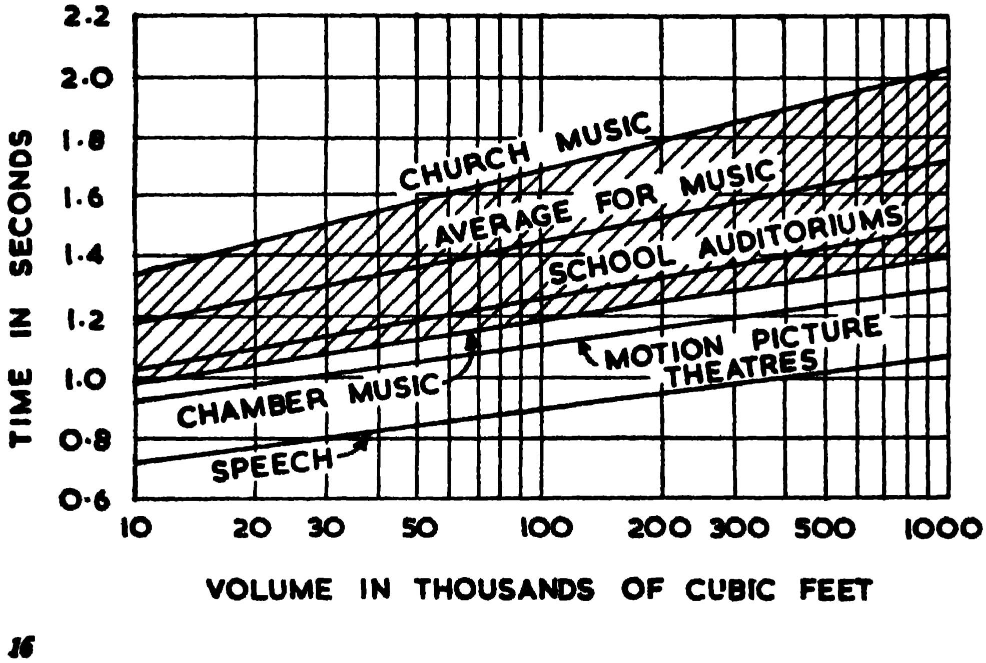


Fig. 2 Optimal reverberation times for different types of music and speech for halls of different volumes in the frequency range 500 to 2,000 Hz

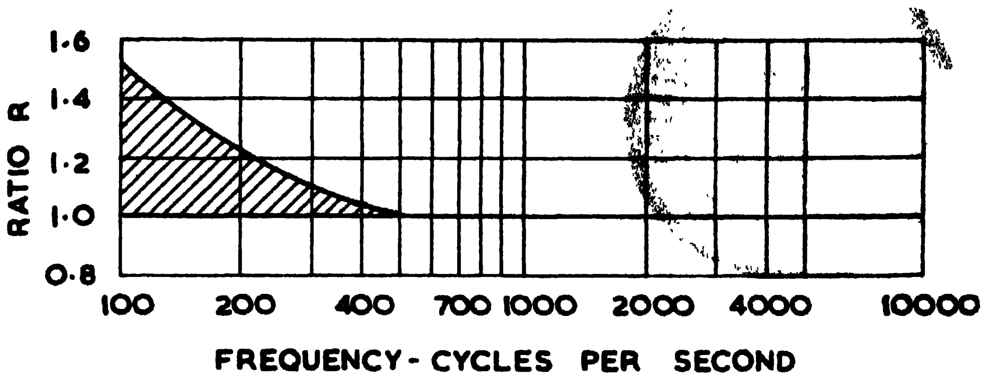


Fig. 3 Desired ratio R of the reverberation time at low frequencies to that in the mid-frequency range

in the frequency range 500 to 2,000 Hz. Fig. 2 gives the range of reverberation times in this frequency range considered acceptable in halls of different sizes. In music halls, it is important that the RT at lower frequencies should be considerably greater than it is in the mid-frequency range, more or less as indicated in Fig. 3. In that case, the bass notes stand out prominently and the hall is said to have warmth and fullness of tone. It is generally difficult, especially in large halls, to keep the RT from falling if the frequency is above 4,000 Hz because of the increasing absorption of sound caused by the air in the room. The tonal quality, called brilliance, depends primarily on adequate high frequency reverberation.

Reverberation is not the only important acoustical characteristic of a music hall, but until a nearly correct reverberation characteristic is achieved, all other virtues and defects in a hall are completely obliterated. The subjective effect of reverberation is something akin to intoxication. In its presence the notes blend together harmoniously and music achieves a tranquillising quality. In excess, it produces a blurring of the auditory perspective. Without reverberation, the notes of music do not blend together and speech becomes crisp and thin.

Next to reverberation, the most important characteristic of a hall is a feature called intimacy. In the parlance of concert hall acoustics, intimacy refers to a time relationship between the sound that reaches the listener directly from the source and the sound that comes next after one reflection. In a small room people talking to each other experience acoustical intimacy because the direct sound is followed almost immediately (within a few milliseconds) by the reflected sounds from walls, ceiling or floor. In a large concert hall, unless the geometry of the interior surfaces is carefully designed, the first reflected sound to reach listeners in some positions may come as many as 30 or 40 milliseconds after the direct sound. Now it is a remarkable property of the human ear that it integrates all the sounds reaching it within time intervals of up to 25 or 30 milliseconds. It is also important that the successive reflections to reach the listener after the direct sound should be of gradually diminishing intensity and should not be separated by long intervals.

Adequate loudness is another important requirement of good acoustics whether the hall is meant for music or speech. If the hall is small (seating less than, say, 500 people) and has the correct reverberation characteristic and intimacy, it is not difficult to achieve sufficient loudness in musical performances even with small groups. On the other hand, in large halls (seating more than 1,000 people), adequate loudness is not always possible for vocal music and particularly for solo performances, and electronic amplification of sound may be necessary. As will be seen presently, there are severe limitations upon the amount of amplification that is possible without distracting attention from the original source of sound. Musicians tend to fall sharply into two categories: those who reject sound amplification under all circumstances and those who desire amplification even when there is no need for it. With more rational attitudes, the experience of both the listeners and the musicians can be more satisfactory.

It is practically impossible to realise good acoustics in a music hall unless the noise level inside the auditorium is kept at the lowest possible value. The noise inside an auditorium may arise from inadequate sound insulation of its walls, ceiling, etc from external sources of noise such as those due to traffic, machinery, etc or may be introduced inadvertently through the airconditioning system. Because music halls are relatively live places, noise can build up to considerably high levels, resulting in soft passages of music being completely drowned in the background noise. The intensity levels over which the musical composition can vary in the hall. known as the dynamic range, is thereby reduced. There remains, however, an irreducible minimum noise in every hall which arises from the breathing, shuffling, etc of the audience.

Echo is another frequent cause of poor acoustics in concert halls, especially those having curved rear walls and spherical domes. A particular form of echo, known as flutter echo, arises when one pair of surfaces (such as the side walls) are reflective and parallel to each other but the others are absorptive and non-parallel. Some sound waves continue to bounce back and forth between the parallel reflective surfaces for a few seconds. A sharp clap made between them produces a sound similar to that of galloping horses, and hence the name flutter echo. The simplest remedy for flutter echo is to break the parallelism between opposite surfaces or to introduce absorptive elements into them. Both of these may be achieved quite simply by designing the plan with non-parallel walls, sloping the floor and ceiling at different inclinations and employing curtains and carpets at appropriate places. Balconies, boxes, niches and many elements used in interior decoration help to avoid flutter echo.

The devices used to avoid flutter echo also help to produce what is called a diffuse state of sound in the hall, and the listeners seem to enjoy part of the reverberant sound coming from all directions, enveloping them, as it were, with music from all sides. One aspect in which the present day high fidelity reproduction of sound falls short of the live performance in a music hall is that with a limited number of loudspeakers it is difficult to produce the same envelopment of the audience by sound as in a concert hall.

If a hall is free from echo and noise, has the correct reverberation characteristic, produces some diffusion of sound, has sufficient intimacy and is not too large for the performing group to produce adequate loudness, there is no reason why the acoustics of a hall should not be at least satisfactory, even if it may not achieve excellence for all types of music in all ears.

Design of music halls

The realisation of these requirements, simple as they may appear, calls for a supreme effort in co-operation between the architect, the acoustician and the proprietors of the hall. It needs some care first of all in the choice of the site itself not only from the point of accessibility, etc but also from the point of how quiet the surroundings will be. If the environment is too noisy, it may be necessary to construct the outer shell in double walls and introduce wide corridors on all sides which will serve as sound locks. If it is realised that in an auditorium the volume of space available per head is usually of the order of 250 cu ft (i.e. about 2 m cube), it becomes quite evident that an effective ventilation system is a primary necessity. If the noise due to the machinery is to be kept within acceptable limits, the plant should be located preferably in a separate building and the supply and return ducts for the air should be carefully designed to attenuate low frequency sounds. A poor ventilation system can ruin the otherwise good acoustics of any hall.

The first concern of an acoustician has always been the reverberation characteristic that he should aim at. Very few of the halls are ever built exclusively as music halls, not to speak of the halls being designed for a particular type of music. Most auditoria serve as multipurpose halls incorporating a whole spectrum of uses including public lectures, music, dance and drama performances. A glance at Fig. 2 shows that these requirements place conflicting demands on the desirable reverberation characteristic of the hall. Can the reverberation time of a hall be varied? If not, what compromise can we make?

In a large hall the change in the total amount of absorption required to vary the RT by even 20 per cent can be quite large and for this reason is prohibitive. Attempts have also been made to change the effective volume of the hall by having ceilings which can be raised or lowered mechanically. But all such solutions are generally so expensive that one should consider whether it would not be worthwhile to build two different halls instead. Reverberation has an objective as well as a subjective aspect. Physically, it is the process of decay of sound energy, but its subjective perception is a more complicated issue of which our knowledge is still very uncertain. It will be shown presently that a suitably designed sound reinforcement system offers some scope for controlling the objective and subjective aspects of reverberation.

In the design of an auditorium, the floor plan of the hall is usually decided upon by the architect before he consults the acoustician. But it is the floor plan that determines, for the most part, the pattern of sound reflections from the walls The three common types of floor plans used by architects in the past were the (i) rectangular, (ii) sector, and (iii) horse-shoe shapes. Most of the celebrated concert halls of the past in Europe and America have floor plans that are basically rectangular. If the hall is not too wide and the side walls are broken up to avoid large areas of parallel surfaces, they tend to produce helpful sound reflections that seem to appeal to the ear in a different way from the reflections from the ceiling. With the rectangular plan, the maximum length of the auditorium is severely limited not only because of the increasing distance of the last rows from the stage but also because of the echo from the rear wall becoming more serious due to greater time delays.

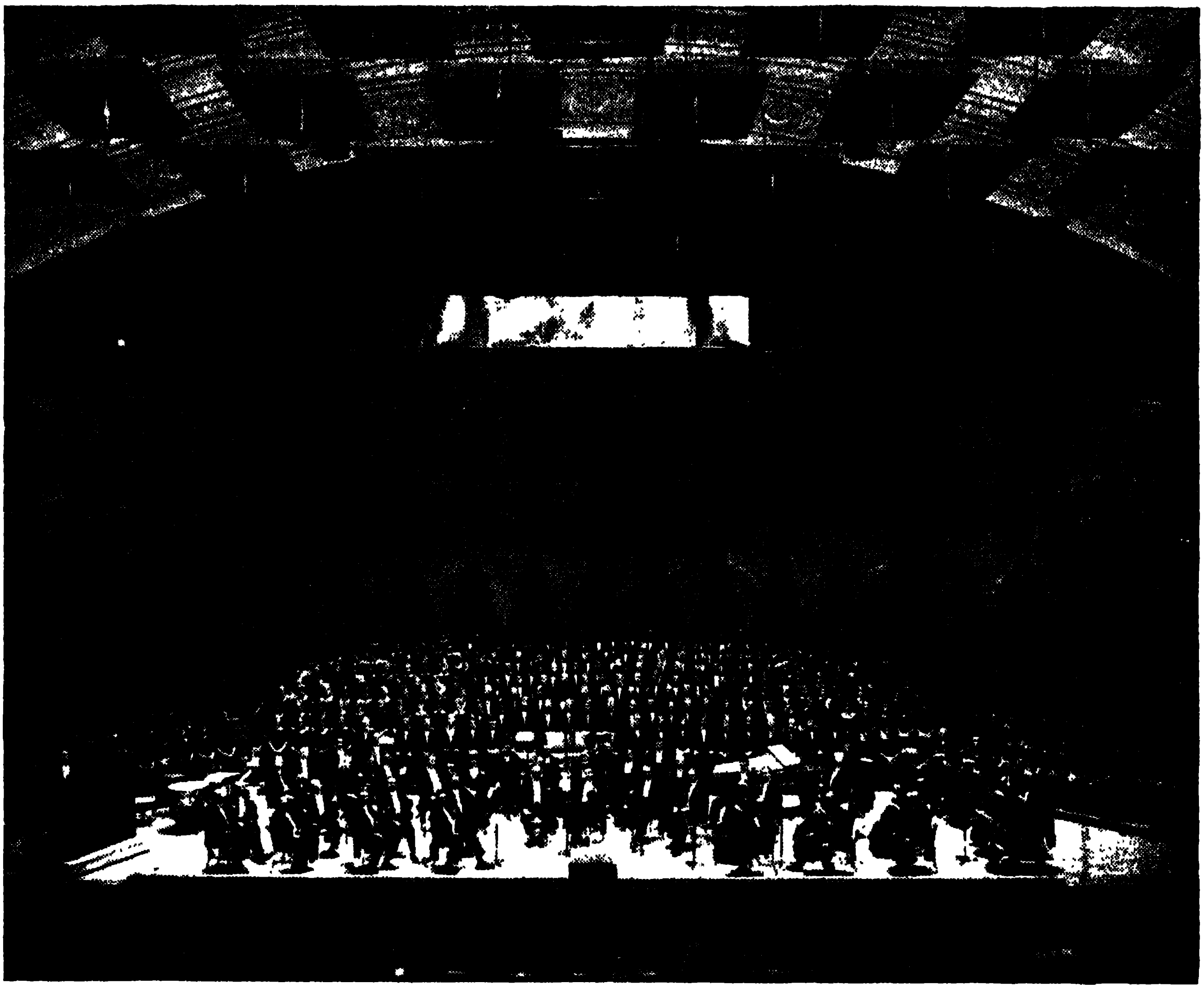


Fig. 4 The steel shell used in the Northrop Memorial Auditorium of the University of Minnesota for concerts

The sector shape came into prominence as the preferred plan for most auditoria because it enabled the audience to be brought closer to the stage, especially if a balcony is provided. In this plan the rear wall is almost always an arc of a circle, and, even when it is heavily treated for absorption, it tends to produce an echo in the front rows or the stage because of the focusing effect of a large concave surface. With an absorptive rear wall, the propagation of sound from the stage tends to be similar to that in a huge horn and does not provide much scope for cross reflections to build up the necessary reverberation. While sector-shaped halls have considerable advantages for motion picture theatres and lectures, they cannot be generally recommended for concerts. The horse-shoe shape is a kind of compromise between the two and, when carefully handled, can have great elegance as well as good reverberation qualities. But great caution must be excercised in employing curved wall surfaces as they tend to focus the sound waves and also to give rise to creeping waves like in St. Paul's Cathedral.

The ceiling provides another important surface that can be used to control the pattern of sound reflections from the stage not only because of its large area, but also because its geometrical and acoustical properties can be chosen in a variety of ways. Broadly speaking it should be reflective whenever the reflections can follow the direct sound in less than say 25 or 30 milliseconds; otherwise it should be absorptive and in no case should cause an echo. It should preferably be broken into smaller surfaces each with a proper inclination to direct sound to different sections of the audience. Geometrical constructions have been developed by which it is possible to design surfaces to produce the desired reflection patterns. The peripheral parts of the ceiling are generally not useful in producing useful reflections, and these areas can be used for absorptive treatment whenever necessary. An important point to remember is that the ceiling of a concert hall should never be made of thin wood or any other material that absorbs most of the low frequencies because of the vibration of the panels.

Stage design

The design of the stage also encounters conflicting requirements. Since practically all desired sounds originate on the stage, it is important that the stage as well as the surfaces coupling the stage to the auditorium be designed in such a way that they favour the transmission of sound into the auditorium. A high stage tower that is frequently found in drama theatres for flying the scenes is very detrimental for music performances, since a large proportion of the sound energy then goes into the tower where it is absorbed or otherwise lost. To adapt a stage with a high tower to music performances, several types of enclosures made in the form of semi-open shells which can be opened or closed have been developed. One such shell made of steel, which can be conveniently folded against the rear wall of the stage when not needed, is shown in Fig. 4. The proscenium opening should be as large as possible so that acoustically the stage and the auditorium form a single space with the same reverberation characteristic. Finally, the stage floor also needs some consideration. Most forms of Indian dance performances require that the stage should respond to the rhythm of the foot steps but without ringing. This requires that the stage be made of wood with an underlay of a damping material and some hollow space beneath. Such a structure would have a high degree of low frequency absorption, which is contrary to the requirements of warmth in musical tones.

Even if the acoustician can get the reverberation times that he desires at various frequencies, he must face the problem of how to obtain the necessary amount of absorption at these frequencies to achieve the desired characteristic. Acoustical materials are notorious for the variability of the absorption produced by them under different circumstances. The effective contribution to the absorption by acoustical materials is influenced by a variety of factors such as their mounting conditions, the geometry of the hall and the position where they are placed, etc in a way that cannot be predicted very well in advance. Even more unpredictable has been the contribution to absorption by the audience in a hall which accounts for well over 50 per cent of the total absorption. The unpredictability was not even suspected until recently and acousticians got into the habit of estimating the audience absorption on the basis of the number of people the hall would accommodate. Some recent analyses by Beranek and the author have established that the audience absorption is more nearly proportional to the area they occupy rather than to their number, and that there is a wide variability in the audience absorption, as indeed one should have expected on the basis of the fact that the audience absorption comes mainly from their clothing and hair.

The best thing that an acoustician could do until now under such circumstances was to base his initial designs on a reasonably acceptable reverberation characteristic and hope to adjust it at a later stage in the construction before the hall was completed. But practical exigencies rarely ever left him in complete command of the situation and if it happened that the hall had excess absorption in some frequency range, it proved to be very expensive generally to remedy the situation. It seems possible, however, that if one were to take a statistical viewpoint of the situation, recognising that the absorptions produced by various materials including the audience are random variables, then the methods of dynamic programming and the techniques of building reliable systems with unreliable components, etc can be brought to bear on the problem to our advantage.

The acoustician should also use some caution in the choice of the furniture. If the RT of the hall is to be reasonably independent of its occupancy (so that the rehearsals can be performed under circumstances close to those of the occupied hall), then the absorption of the seats should on the average have a similar characteristic to that of the audience. This is not possible in general unless the chairs are heavily upholstered and covered with a porous fabric. Leather and plastic covered seats generally tend to exhibit a drum-like resonance with a strong characteristic absorption in the low frequency range.

Acousticians have resorted to experimenting with models in the hope of obtaining information concerning the hall before it is actually constructed. The earliest experiments studied the reflections of different cross-sections by ripple tanks and spark pulse photographs with the object of locating sound foci, etc. In more recent experiments, three dimensional models scaled down to 1/10 the original size have been employed. Reverberation-free recordings, played inside these models at correspondingly higher frequencies, have been recorded and subsequently reproduced at the normal frequencies to hear the effect of reverberation introduced by the model. One of the chief difficulties with this technique has been the scaling of the acoustic impedance properties of the materials. A more recent technique is to record the music in an anechoic chamber (a room with nearly 100 per cent absorbing surfaces) and add to it the reverberation characteristic of the proposed hall by processing the signal on a computer according to a programme that incorporates the reflection pattern of the sound in the hall and then listen to it again in an anechoic chamber.

Figures 1 and 5 show photographs of the Centenary Auditorium of Madras University, a large multipurpose hall accommodating 3,250 people. The floor plan of this hall is basically octagonal in shape with the balcony running on three sides. The canopy seen on the top left corner of Fig. 1 is designed to reflect sounds to the main balcony opposite the stage seen in Fig. 5. The loudspeaker assembly is also seen in Fig. 1 just above the proscenium. The hall has a mid-frequency RT of 1·7 secs rising to 2·3 secs at 125 Hz and dropping to 1·4 secs at 6,000 Hz when occupied. A rather noisy airconditioning plant located close to the hall mars the otherwise highly satisfactory acoustical conditions in the hall.

Electrical sound reinforcement

In most halls seating more than about 500 people, the necessity for sound reinforcement by electrical amplification arises for speeches as well as for solo music at some time or the other. The design of the sound reinforcement system should form an integral part of the acoustical design of the auditoria because the electrical amplification of sound can have important effects on the actual as well as perceived reverberation of the hall. In the first instance, the presence of a sound reinforcement system in the hall tends to prolong the actual RT because the microphone not only picks up the direct sound but also the decaying reverberant sound and passes it on for amplification giving it a new lease of life. In fact, in the limiting case where the sound system goes into oscillation, the decay rate of sound energy is zero and the reverberation time becomes effectively infinite. It is thus clear that by a proper use of sound amplification, the effective RT can be increased considerably beyond its normal value, but this can be achieved only at the expense of the dynamic range available in the hall.

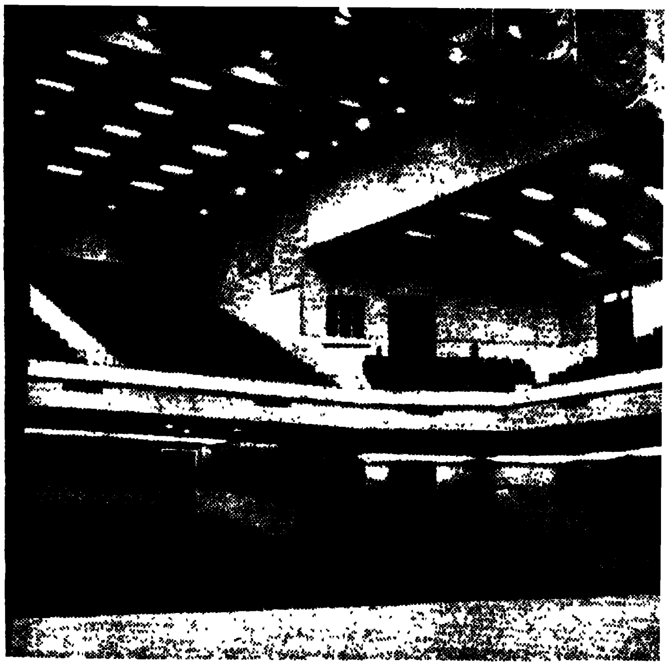


Fig. 5 A view of the rear of the Centenary Auditorium as seen from the stage

At this point we must consider an important subjective effect on the perception of sound known as the Haas Effect. To put it briefly, as applied to sound reinforcement systems, it states that so long as the sound from the loudspeaker follows the live voice with a delay of 5 to 35 milliseconds, and the intensity level of the reproduced sound does not exceed that of the live voice by 8 dB (decibels), the ear generally does not recognise the presence of the loudspeaker and identifies the source of the sound with the live source. It is also true, however, that when this condition is satisfied, the ear perceives less of the reverberation of the hall, the primary subjective effect being one of enhanced loudness and clarity. On the other hand, when the sound from the loudspeaker reaches the listener earlier than the live voice, or if its intensity level exceeds that of the live voice by 10 dB or more, the audience not only becomes aware of the loudspeaker as the source of sound but also perceives that the sound has a more reverberant quality.

These observations indicate that the electrical amplification of sound offers considerable scope for enhancing or decreasing the perceived reverberation in a hall. As a matter of fact, the technique for controlling the actual reverberation time of a hall by electrical amplification of frequency components in a selected range has been employed successfully under the name of assisted reverberation to improve the low frequency RT of a hall.

THE OCEAN-FLOOR IS SPREADING!

RAMA

For long, it was thought that the Earth's crust was an immovable sphere. Seismic and magnetic observations have now provided enough evidence to show that the crust consists of movable plates, and that the ocean-bed has been spreading

THE sea covers about 70 per cent of the Earth's surface. Beneath the placid waters lies a large mass of the crust, furrowed, wrinkled and magnetised, reflecting what is going on within. A large part of the ocean-floor is, of course, flat, lying at a depth of about 4 km. There are furrows, as deep as 10 to 11 km, and a few mountains too. Explorations during the last 15 years have revealed ridges running right across the middle of the oceans. At a few places, they pop out of water as islands.

Curiously enough, the sea-floor is younger than the land, though the oceans and the land have been in existence for about the same time. The Earth, we can now say with some certainty, condensed from the solar gaseous nebula and dust about 4½ billion years ago. Thereafter water appeared on its surface in about a billion years time, out of the hydrated silicate minerals. Most of the land mass also came into existence about this time. Rocks on the land vary in age from 0 to 3½ billion years; around Bangalore, they are about 3½ billion years old. In contrast, rocks picked from the ocean-floor are always found to be younger than 100 to 200 million years. Besides, sediments on the sea-floor are less than a km in depth, and represent a deposition of less than 100 million years. In fact, in some places they are so thin that the sea-floor is almost bare. All of which shows that the ocean-floor is of recent origin, though the oceans themselves are much older. And this has given rise to the important geological theory of ocean-floor spreading: at the mid-ocean ridges the crust is being pulled apart and the gap is being filled by a new crust.

A good deal of information about the physiography of the ocean-floor has come from seismological and gravitational observations. The floor crust is constituted exclusively of basalt, fractured and faulted at places. According to J. T. Wilson, the extensive cross-faults, at right angles to the ridges, are results of crustal motion and are, therefore, indicators of its past history.

Earthquakes do not occur randomly on the surface of the Earth. They are mainly restricted to the circumPacific belt of trench systems, the young fold mountains of the Alpine-Himalayan belt and the crests of the mid-ocean ridges in that order of intensity. Seismic activity at the ridge crests and faults

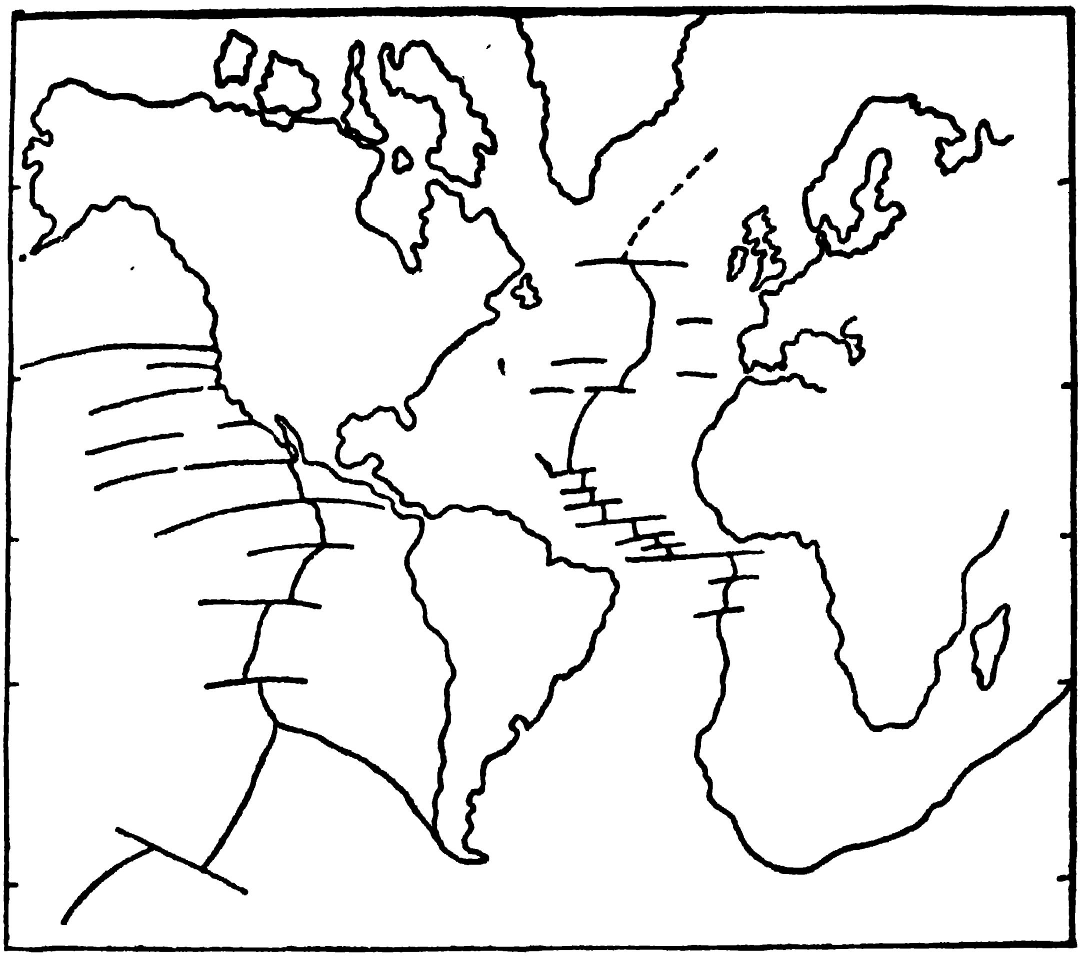
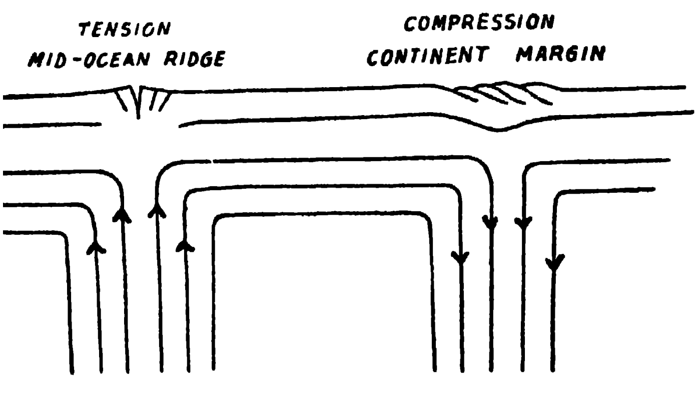


Fig. 1 Representation of crustal blocks having boundaries at the mid-Atlantic ridge and at the east Pacific rise

occurs at depths less than 10 to 20 km. Such shallow-focus earthquakes occur in the young fold mountains and the trench systems also. But here one also observes intermediate and deep-focus earthquakes up to a depth of about 700 km.

Fig. 2 The convection cells in the Earth's upper mantle



Complementary processes

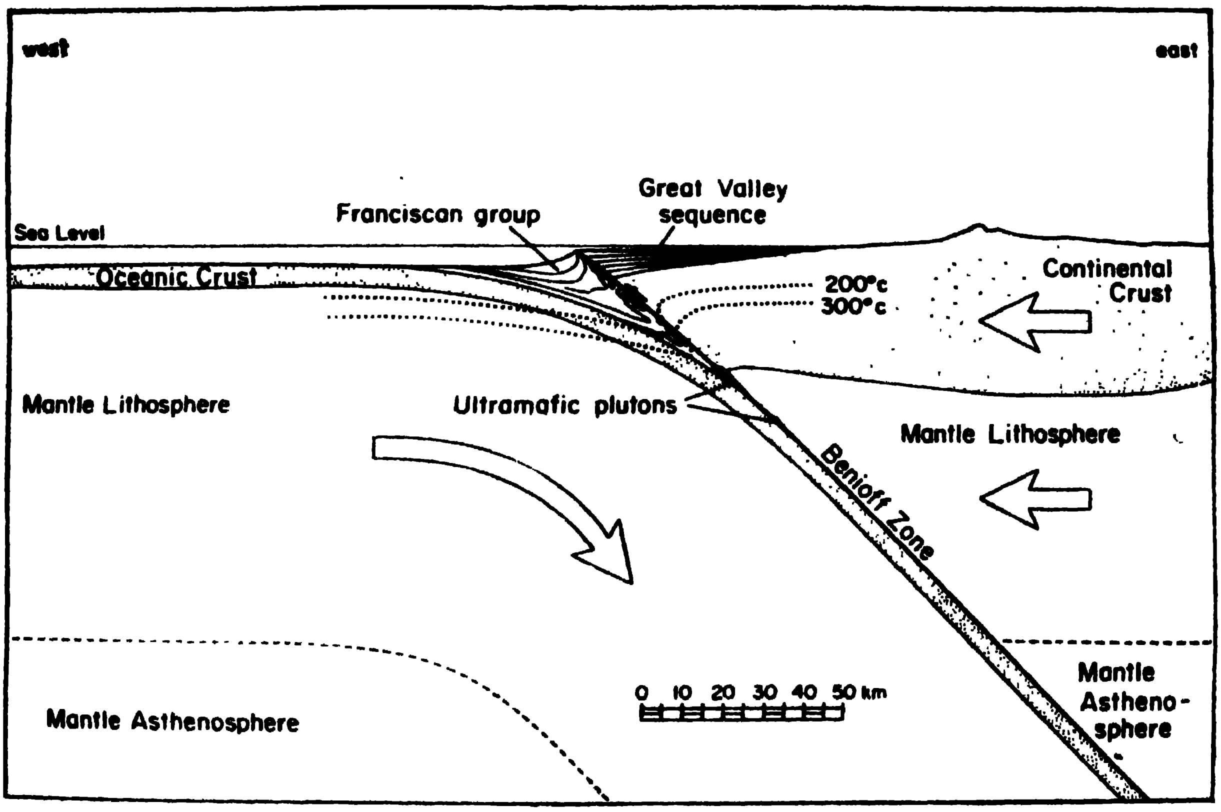
Obviously, some changes are taking place in the Earth's crust where earthquakes are frequent. According to the hypothesis of sea-floor spreading, the shallow and the deep-focus lines of seismic activity represent the linear regions where two different but complementary processes are at work in the Earth's upper mantle. Along the mid-ocean ridges, the shallow-focus lines, a new crust is formed; in the trench regions, the deep-focus lines, some of the old crust is partly resorbed. The oceanic crust is thus derived from the mantle by partial fusion and chemical modification beneath the ridge crests and returned in part to the mantle beneath the trench systems. In other words, the crust is under extension at the ridge crests and under compression near the trench systems. The crust moves as a rigid plate from the ridges towards the trenches, as if carried by a conveyor belt. What is the mechanism that drives the crust? It is believed that this behaviour of the crust is caused by the convection cells in the Earth's mantle; the crust, along with its sediments, moves with the upper mantle. Extensive fault systems, running perpendicular to the ridges, have been located. The fault systems indicate the motion of the crust and lend strong support to the hypothesis of ocean-floor spreading. The conclusive proof for the phenomenon, however, came from a recent unexpected quarter — magnetic observations.

The Earth's present magnetic field can be approximated to a dipole field; the magnetic poles are slightly shifted from the geographic poles. Minute magnetic minerals crystallising out of molten lava acquire some magnetisation in the direction of the ambient Earth's magnetic field as the lava cools and solidifies into rocks. Measurements of this magnetisation in rocks belonging to different geological periods gave a surprising result: about half of the volcanic rock systems are aligned in the direction of the present-day field while the other half are aligned in the opposite direction. This could be explained in two ways : (*i*) the Earth's magnetic field might have been reversing its direction frequently, or (*ii*) the mineralogy of half of the rocks is such that it acquires magnetisation in a direction opposite to the applied field. Though the second explanation is theoretically and experimentally possible, such mineralogy is found to be rare in natural rocks. Further, baked contacts are usually found to be magnetised in the same direction as solidified lava. It, therefore, seems probable that the Earth's field may have been reversing its direction off and on (see page 30).

Chronological order

Cox and R. R. Doell measured the direction of the magnetic fields in accurately dated young basaltic rocks and found that all rocks younger than 700,000 years are magnetised in the direction of the normal field (i.e. present-day field). Rocks aged between 700,000 and 900,000 years are magnetised in the opposite direction, older ones again normal, still older ones opposite, indicating that the Earth's magnetic field has been changing its direction. They have given the history of reversals for the last 4 million years. Meanwhile, an independent verification of the chronology of the reversals came from another quarter. Rivers and winds sweep dust into the oceans. These dust particles, being parts of rocks, are also tiny magnets. As they settle slowly on the ocean-floor, some of them may get aligned in the direction of the Earth's magnetic field, though most fall randomly. Measurements of the magnetisation of this dust-mud from the ocean-bed have shown

Fig. 3 A model of the oceanic crust being dragged into the mantle near the continental margin



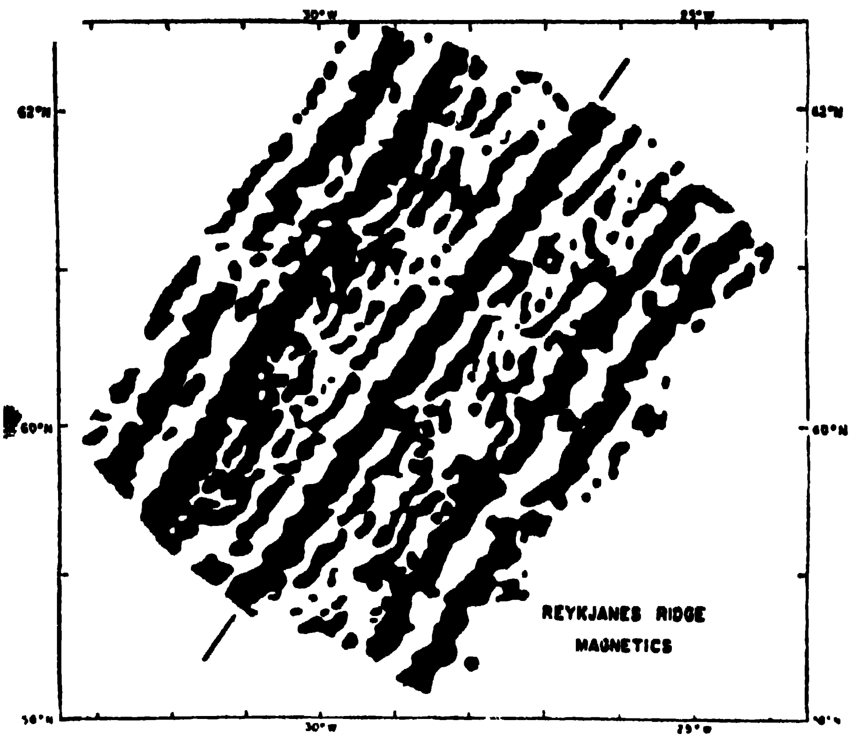


Fig. 4 (left) A map of the magnetic survey of the Reykjanes Ridge in northern Atlantic. Note the linear anomalies placed symmetrical and parallel to the axis of the ridge

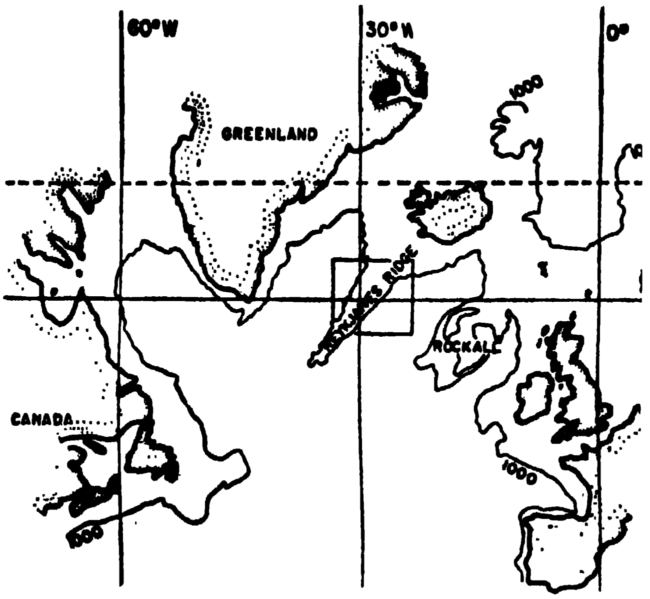


Fig. 5 (below) The geographical position of the Reykjanes Ridge

that the magnetisation is in the direction of the normal field in sediments deposited during the last 700,000 years and in the opposite direction in sediments aged 700,000 years to 900,000 years and so on.

Again, measurements of the magnetic field on the Earth's surface do not exactly correspond to the value theoretically predicted for a dipole or some modification thereof; on land, there are small and irregular regional variations. This is because the measured field is the field due to dipole and also due to the magnetisation in rocks. And because some rocks have stronger magnetisation than others, they can cause anomalies, usually of the order of 1 to 2 per cent of the dipole field. This fact is used in locating mineral ore deposits by aerial magnetic surveys.

Magnetic surveys of the ocean-beds revealed some unique linear anomalies, called the Raff-Mason lines. Along the mid-ocean ridges, the anomalies are found to be not only parallel to the ridges but also symmetrically positioned. Vine and Matthews explained that these anomalies were caused by ocean-floor spreading and the new crust acquiring magnetisation in the direction of the ambient field which may be normal or reversed at that time. The first anomaly should then represent the crustal material which solidified 700,000 years ago and since moved from the ridge to its present position. Correlating the positions of the various anomalies with the reversal chronology, the velocity of floor-spreading can be calculated. It is found to be in the range of 1 to 8 cm a year; 1 cm in the northern Atlantic and 8 cm in equatorial Pacific.

The symmetrical linear anomalies have been observed for several hundred km on either side of the ridge. One can now reverse the argument: assuming the rate of spreading to be constant, one can work out the chronology of magnetic reversals far back in time. Thus anomaly No. 31 corresponds to a

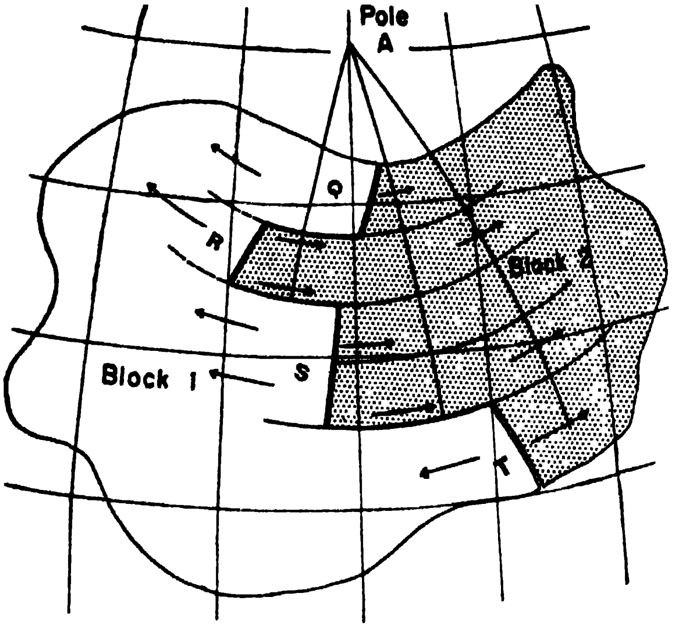


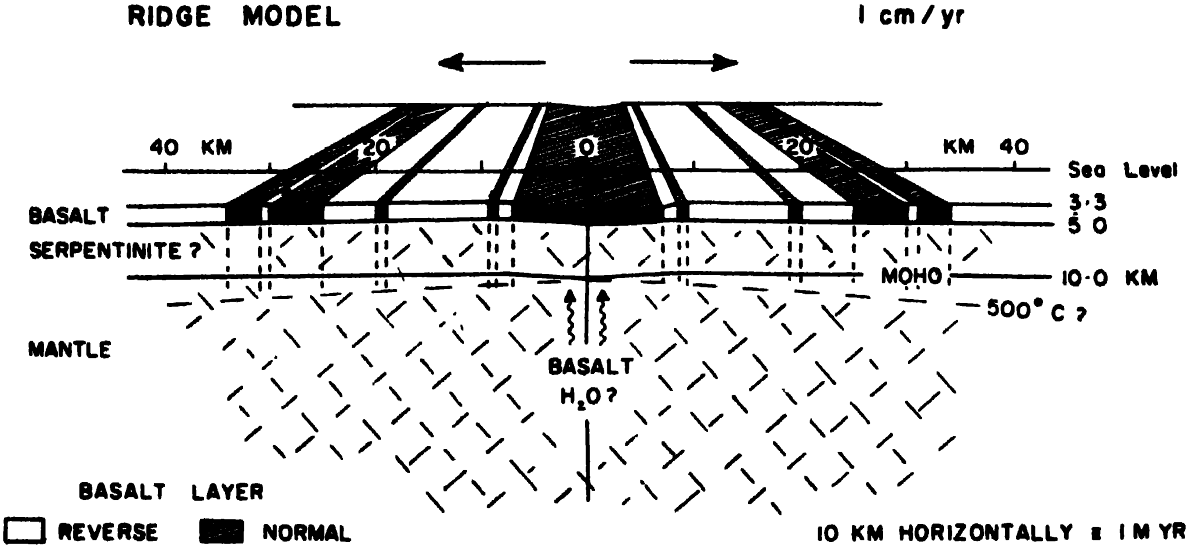
Fig. 6 A model of movement of Block 2 (shaded portion) with respect to Block 1 on the spherical Earth

Fig. 7 The Vine and Matthews model of linear anomalies in terms of reversal chronology and ocean-floor spreading. The shaded areas represent the normal magnetic field and the unshaded areas the reversed field. At the two ends of the model are the trench systems

period about 65 million years ago. Reversals in the past appear somewhat less frequent.

Morgan attempted to fit the fairly large amount of data on the physiography of ridges, cross-faults and rates of spreading at various locations obtained during the last decade into a simple and geometrically consistent pattern. He figured out that the Earth's crust consisted of about 20 rigid blocks or plates, their boundaries being defined by tectonic activity. The first boundary is the ridge type at which new crustal material is formed; the second is the trench type at which crustal material is destroyed. The gap between two land marks on either side of a trench gradually decreases and at least one land mark eventually disappears into the trench floor. The compressive system in which the distance between two points decreases and the crust thickens, e.g. folded mountains, is included in the second type.

The crustal block is considered perfectly rigid, i.e., the distance between any two points on the same block remains the same. A block on a sphere can be moved to any other orientation by a single rotation about a properly chosen axis. The relative motion between two such rigid blocks can thus be defined by three parameters, two for the pole of rotation and one for the degree of angular velocity The faults define the latitutde circles and the lines perpendicular to the faults, i.e., longitudes, meet at the pole of rotation. The velocity of one block relative to the other will vary with their common boundary, being maximum at the equator of rotation and zero at the pole. If the model is correct, the pole positions computed from the fault system and from the



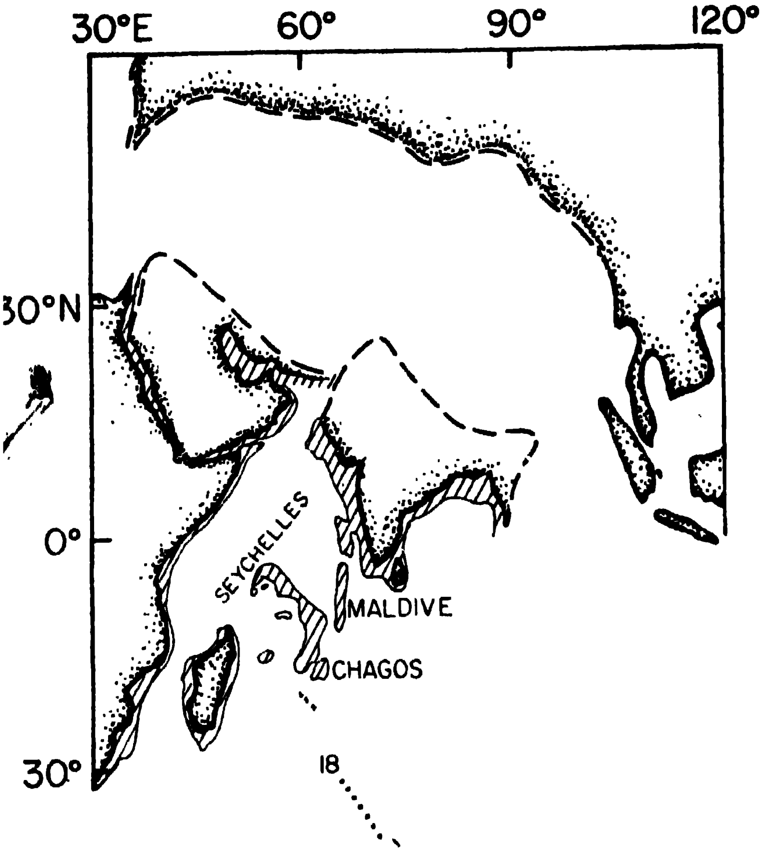


Fig. 8 India's geographical position during the period 40 to 65 million years ago. Note that at this period the equator passed through India. It is estimated that from 40 to 50 degrees South, India has drifted to 10 to 30 degrees North latitude in about 100 million years

measured spreading rates between two adjacent plates should coincide. And it has been found to be approximately so. By vector addition of angular velocities, one can compute the relative rotation between any two plates, and thus check on the consistency of various assigned values.

Le Pichon followed up Morgan's treatment using only six plates. He deduced rates of compression in the active mountain belts and crustal-shortening in the trench systems by vectorially summing up the relative movements between pairs of plates about their centres of rotation. The rates of shortening are the highest in the Himalayas and in the trench systems.

The plate movement provides a long-sought explanation for continental drift. If an upwelling process in the mantle starts at a point beneath a continent, the continent will split and drift apart. Lateral spreading from the point of rift will form a new ocean basin; the continent, riding on a rigid conveyor belt of the upper mantle material, moves towards the trench system. Large parts of the Atlantic and the Indian Ocean, having ocean basins with a medium ridge and trailing edges of drifting continents, are examples of such a phenomenon.

Alternatively, if rifting occurs in the oceanic crust, a new crust is formed at the rift and the old crust is resorbed at the trenches. This pertains to most of the Pacific Ocean. A third possibility is that two continents may ultimately come together at a trench system, producing high mountains like the Himalayas, which resulted from the collision of India with Eurasia, and the Alps which resulted from the collision of Africa with Eurasia.

Indian Ocean

Knowing the present relative movements between different plates, we can work out what the situation was like in the past. But the situation in the Indian Ocean is slightly confused when one goes far back in time. Between Australia and the Antarctica, the sequence could be traced only for the past 40 million years; the earlier sequence is missing, indicating that the separation of these two continents was the last stage in the fragmentation of the southern super continent, called the Gondwanaland, which once included South America, Africa, India, Australia and the Antarctica. It is interesting to note that such details as the recent separation of the Antarctica and Australia and some form of a sub-continental circulation producing new ocean basins and the separation of continental fragments were worked out by Wagener in 1915 and by Holmes in 1928. The implications of these ideas and the new data on ocean floor-spreading are far-reaching. Both the magnetic anomalies and the distribution of sediments on the ocean-floor suggest some variations in ocean-floor spreading rates and discontinuities in spreading in the north Atlantic and the north-west Indian Ocean.

India occupies a special position in all this. It is believed to have drifted apart from the southern hemisphere to its present position in about 100 to 150 million years. The paleomagnetic work done on the Deccan and Raj Mahal basalts by Drs. P. W. Sahasrabudhe and C. Radhakrishnamurthy of the Tata Institute of Fundamental Research has indicated that these basalts were laid at 40 to 50 degrees south latitude. Further, their dating by the Potassium-Argon (K-Ar) method shows that they were laid sometime 60 to 100 million years ago. This would mean that not only India's total drift has been the largest, about 10,000 km, but also that the drift velocity must have been very high, about 10 cm per year which exceeds the maximum velocity of 8 cm per year observed for equatorial Pacific. However, no explanation for this discrepancy is yet available.

ROUND-UP OF RESEARCH

The Pill Again

TWO American scientists have shown that contraceptive pills do not reduce women's capacity to make love. The scientists, Drs. Richard Udry and Naomi M. Morris of the Department of Maternal and Child Health, School of Public Health, University of North Carolina, USA, have in fact studied the effects of contraceptive pills on the distribution of sexual activity in the menstrual cycle. Their findings are reported in *Nature* (*227,* p. 502, 1 August 1970).

Contraceptive pills usually contain the two substances, oestrogen and progestogen, which have actions similar to that of the female hormones, oestradiol and progesterone. Oestradiol controls ovulation while progesterone is the hormone of the corpus luteum, a yellow body formed in the ovary after the rupture of an ovarian follicle and the subsequent expulsion of the ovum.

Previous experiments on the sexual behaviour of rhesus monkeys had indicated that monkeys receiving only oestrogen maintained a high rate of sexual activity, but their activity decreased when they were given progestogen as well. Women taking pills with a high dose of progestogen have also complained to some doctors of loss of desire. These results indicated that progestogenic components of oral contraceptives might affect sexual behaviour.

In the study reported in *Nature*, the two American scientists used 51 married women, most of them wives of graduate students. The women were randomly divided into three groups irrespective of age or racial composition. Every day they recorded whether or not they had menstruated, whether they had intercourse and/or orgasm. They also answered questions as to how they felt and whether their husbands had wanted intercourse.

For the first cycle of participation (a cycle began with the first day of menstrual bleeding), the women were not given any pills, but only sent in their daily records. After the first cycle, one group was given ordinary contraceptive pills, a second group contraceptive pills with an excess of progestogen and the third group milk sugar pills looking identical to the contraceptive pills. All the women sent in data for at least three cycles, one when they were taking no pills and two during which they were taking pills.

It was found that the rates of intercourse when no pills were being taken reached a peak half-way through the monthly cycle and were depressed during the luteal phase in the second half of the cycle. However, for women taking the pills, intercourse with their husbands reached a peak in the second part of the month which normally would have been the luteal phase had ovulation occurred. The fact that orgasms occurred more frequently during this period indicated that it was the woman's own sexual urges which were being affected. In fact, around the 20th day, more than 40 per cent of the women reported intercourse the night before, half as many again as those not on the pill.

The results of the experiment were a surprise to Drs. Udry and Morris since, on the basis of previous experiments, they had expected that women receiving oral contraceptives with excess of progestogen would show decreased sexual activity all through the whole cycle.

The scientists now suggest that normally a woman's urge is dampened when her body produces the natural progesterone on ovulation. The contraceptive pills used in the experiment work by inhibiting ovulation and, hence, the natural hormone. This explains the disappearance of the characteristic luteal depression of sexual activity.

Carbon Fibres

IN the last few years, carbon fibres have found themselves a unique place in the technological world. They are being used in a class of materials known as composites which have very high tensile strength — equal to that of steel — but with very much lower density. In fact, the Rolls-Royce RB-211 turbo-fan engines incorporate considerable amounts of a composite material called Hyfil, a resin reinforced with carbon fibres. In Hyfil, Rolls-Royce have used carbon fibres with a tensile strength as high as 25,000 kg per sq cm.

Drs. H. M. Hawthorne, C. Baker, R. H. Bentall and K. R. Linger of the Centre for Materials Research, University of British Columbia, Vancouver, Canada, have now reported the manufacture of carbon fibres from ordinary pitch. Their results, if confirmed, could significantly reduce the cost of manufacture of these fibres. The remarkable thing is that the fibres produced from pitch have the same high tensile strength and modulus as those produced from more sophisticated materials which have been used so far for carbon fibre production.

The manufacture of carbon fibres, though a commercial secret, is known to start from carefully prepared samples of synthetic fibres, often rayon or polyacrylonitrile (PAN). The textile fibres are subjected to a series of heat treatments which convert them into fibres of pure carbon. The first step is the oxidation of the fibre in air at 200° to 300°C. The next stage is the carbonisation which calls for a temperature of around 1,000°C. A final heat treatment converts the fibre to graphite at 2,100° to 3,000°C.

In the method of manufacture reported in *Nature* (*227*, p. 946, 29 August 1970) the Canadian scientists used asphalt as the raw material. They refined it by distillation and then spun it into a fibrous form suitable for heat treatment. The fibres were then subjected to controlled oxidation and carbonisation similar to methods previously used. The resulting carbon fibres were elongated under carefully controlled conditions during graphitisation (in the temperature range 2,000° to 2,800°C). It is now understood that the high modulus and, to some extent, the high strength of carbon fibres is a consequence of the high degree of orientation and the small size of the graphite crystallites. The effect of the elongation technique is to orient the crystallites, tending to align the graphite based planes parallel to the fibre axis.

Dr. H. M. Hawthorne and his colleagues show, from a series of photographs with an electron microscope that the atomic structure of the fibres produced from pitch is similar to that previously observed in graphite fibres produced from rayon and PAN. A comparison between the modulus of a number of graphite fibres produced by hot-stretching to different elongations indicates that fibres produced from pitch have a pronounced degree of orientation. This is further supported by electron diffraction studies. The scientists claim that to date oriented graphite fibres have been produced from pitch with strengths up to 27,000 kg per sq cm comparable with that from fibres produced from more sophisticated materials.

Multiple Sclerosis

TWO research papers whose further development may lead to an understanding of the cause of multiple sclerosis have now appeared in *Nature* (*227*, p. 1132 and 1133, 12 September 1970).

Multiple sclerosis is a disease of the nervous system, most commonly affecting young adults, in which patchy degenerative changes occur in the myelin layer surrounding the nerve fibres in the brain, spinal cord and optic nerves, followed by scars in the neurologia. The presenting symptoms can be diverse, ranging from diplopia or double vision to weakness or unsteadiness of a limb.

While the explanation behind the loss of the white fatty matter myelin is unknown, Drs. J. P. Dickinson, K. M. Jones, S. R. Aparicio and C. E. Lumsden of the Multiple Sclerosis Research Unit, Department of Pathology, University of Leeds, School of Medicine, England, have shown that the giant molecular complex, myelin, is not the stable chemical that it was thought to be. They have attempted the preparation of a chemically pure myelin from bovine cerebral white matter and found that the myelin they prepared collapsed a couple of hours after the death of the animal with the release of a specific protein material. Using standard methods like electrophoresis and chromatography, the British doctors have shown that this protein is identical with the basic encephalitogenic protein of the central nervous tissue. The conditions that could cause the collapse of myelin have still to be understood, but the instability of the myelin structure reported by the Leeds group may be at the root of the trouble in multiple sclerosis.

Among other things, myelin is predominantly composed of fat-like substances made up of long chains of 18 to 24 carbon atoms. It is the most stable membrane known, and it is now thought that the long-chain fatty acids contribute to its stability. The starting point for the manufacture of fatty substances containing up to 24 carbon atoms may be in the diet of fats like cerebrosides made up of 18 carbon atoms. It has been known for some years that diet deficiencies can cause multiple sclerosis.

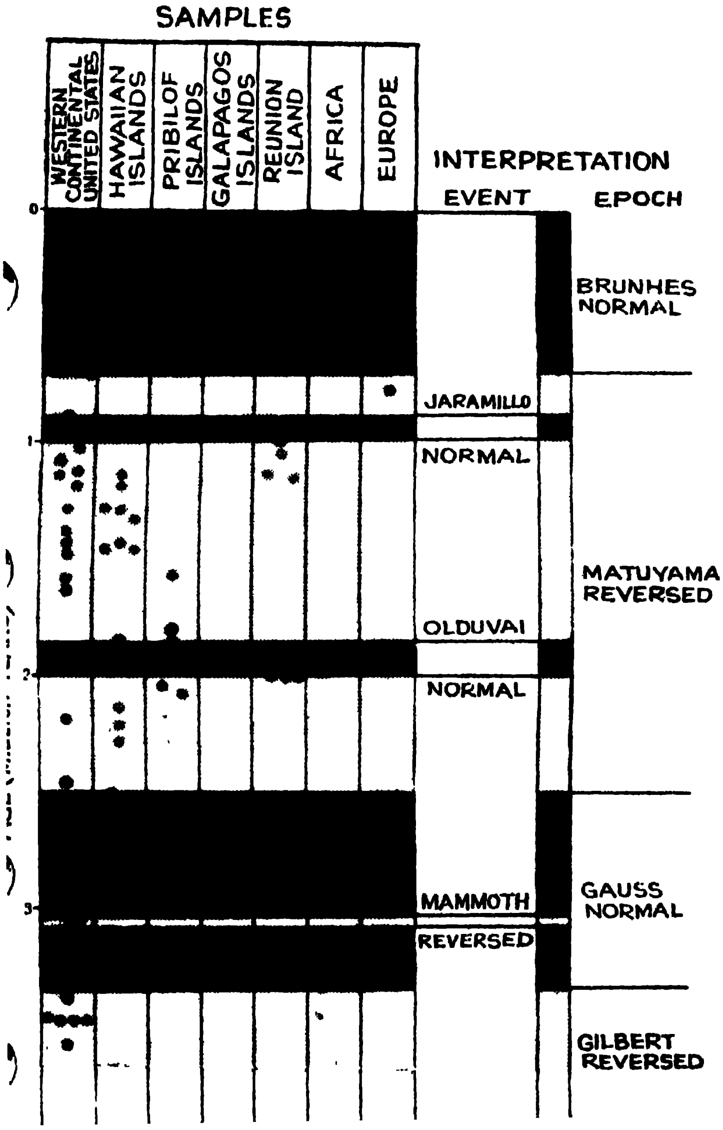
Drs. Frank M. Yatsu and Sylvia Moss, Department of Neurology, University of California Medical Centre, San Francisco, California, USA, have now studied the developmental pattern of fatty acid elongation in rat brains. They have identified, by combined gas-liquid chromatography and mass spectroscopy, fatty acids extracted from mitochondria isolated from rat brains, 5, 10, 15 and 20 days of age and in adulthood. The American neurologists report that the pattern of fatty acid elongation changes with brain growth and development. They find that young brains mainly form chains of 22 and 24 carbon atoms, whereas older brains form 18 and 20 atom chains; the fatty acid elongation reaches the maximum rate during myelination. Their findings support the view that a fault in the lengthening system during the early stages of brain growth and development may lead to a poor quality myelin and a predisposition to multiple sclerosis.

K. A. Neelakantan

Geomagnetic Reversals and Faunal Extinction

IT is now well known that the Earth's magnetic field reverses once in about a million years or so. That is, the magnetic north pole becomes the south and vice versa. This was discovered from studies of remnant magnetisation — a study known as paleomagnetism — in rocks. When rocks are formed (that is, when the lava cools and solidifies) they memorise the direction of the Earth's magnetic field. Assuming that the rocks do not change their orientation, subsequent changes in the field do not affect their memory. Rocks formed during different times will indicate the direction of magnetic fields which existed during their formation.

Analyses of rocks, particularly from the volcanic regions of Hawaii, formed during the past four million years (whose ages may be determined by potassium-argon dating) have revealed the existence of four major epochs of magnetic fields with alternating polarities. Within epochs, however, there occur periods of the opposite polarity for a short time which are called events. The present epoch — termed Brunhes Normal — began about 700,000 years ago. The epochs and events of the past four million years are shown in the figure (left). The exact cause of the geomagnetic field reversals has not been established so far. Nor is it known whether the geomagnetic field changes its direction after slowly diminishing its magnitude to zero and then going to the opposite direction or by sudden flipping.



Ocean sediments behave in a similar way to rocks in memorising the ancient magnetic field of the Earth. Sediments are slowly settling fine particles. They acquire a resultant magnetism in the direction of the Earth's field during their deposition. Magnetic reversals have been observed in ocean sediments; and by knowing the rate of deposition of sediments, the age of magnetic reversals can be measured. Both the rocks and sediments point to the various periods of geomagnetic activity as mentioned earlier. It was found, in ocean sediments, that coincident with the magnetic reversals, there was a sudden extinction of a group of *Radiolaria* named *Pterocanium prismatium*. The disappearance of this faunal species was supposed to be in some way connected with the disappearance of the Earth's magnetic field during that time and it was argued that cosmic rays which are normally deflected by the Earth's magnetic field reached the Earth and caused harmful mutations, resulting in the extinction of the species. But the increase in radiation dosage owing to the absence of a geomagnetic field in itself would not be sufficient to cause the extinction of the species.

In a recent paper on the subject, J. P. Kennett and N. D. Watkins (*Nature*, 29 August 1970) reported the existence of volcanic maxima — a period of high volcanic activity — during the periods of geomagnetic reversals. This was inferred from the presence of large amounts of volcanic ash in the sediments coincident with the geomagnetic reversals. Kennett and Watkins propose that the upper mantle activity (causing the volcanoes) and geomagnetic reversals may be related and conclude that the faunal extinction could be due to the sudden climatic changes caused by the huge inputs of volcanic dust particles into the Earth's atmosphere. This dust acts as a blanket for solar radiation causing a worldwide cooling. This might result in the extinction of the *Radiolaria* which are very sensitive to temperature changes.

V. S. Venkatavaradan

Science Today January 1971

FROM OUR LABS

Combating Malnutrition

PROTEIN Calorie Malnutrition (PCM) is a major cause of death and disease among children, more so in the pre-school age group. Nearly 40 per cent of the total deaths in our country occur among children under 4 years. The corresponding figures for the developed countries of the West are around 3 to 7 per cent. Malnutrition is largely responsible for these deaths. Apart from this, malnutrition stunts the growth of survivors who remain at substandard heights and weights. There is also the danger of their learning ability being impaired. Further, the ill-effects of PCM during the crucial years of development cannot be reversed by providing children better nutrition at a later age. This vulnerable group of our population, therefore, needs adequate protection from these potential health hazards.

The use of processed foods is often suggested to meet situations of this type. But conditions in India are such that this approach does not work. Over 70 per cent of our people live in villages. They are poor and cannot afford the food they ought to eat. Moreover, difficulties in transport and storage of these sophisticated foods arise. The only solution is therefore to use locally available low-cost foods which could ward off PCM.

The National Institute of Nutrition, Hyderabad, considered all these factors before planning a model feeding programme. Emphasis in this project was on building into it an element of self-generation. The cooperation of the village community was enlisted even from the stage of planning.

Many recipes were prepared using the available base-line data on nutritional content. It was ensured that the ingredients used were locally available in sufficient amounts for feeding several hundred children over a long period. Kheera pongal, sweet dhal, rice porridge, biscuits made from groundnut and wheat flour, and wheat—green gram laddus were tested for acceptability by the village children and the community. Wheat—green gram laddus were the best accepted.

The recipe had the following ingredients (per child per day)

Green gram	20 gm
Groundnuts	8 gm
Wheat flour	30 gm
Sugar	20 gm

The recipe provided about 10 gm protein, 300 calories, 4 gm fat and small amounts of minerals and vitamins. The cost of the ingredients worked out to 10 paise/child/day.

Kuntloor, a village with about 1,500 people and with an estimated 200 pre-school children, was selected for the study. The Institute was committed to meet, in the initial stages of the programme, the cost of food materials. The local organisations agreed to provide the services for operating the programme and procuring the raw foods. This pilot study with about 100 pre-school children soon became quite popular. The programme was then extended to another nearby village, Koheda.

In both the villages, about 160 pre-school children were fed the supplement daily. Two hundred children of comparable ages and socio-economic status from the nearby localities formed the control group. These children were not given the recipe. Experience with earlier feeding programmes showed that children who received such supplements reduced their home food intake to a corresponding extent. Thus, these

Percentage prevalence of nutritional deficiency signs in the control and experimental children

Group	No.	Hair changes			Moon face	Kwashiorkor	Marasmus
		Sparse	Discoloured	Easy pluckability			
Experimental (received supplement)	159	5.0	6.3	4.4	5.7	—	1.9
Control (no supplement given) ..	200	15.0	15.0	7.5	6.0	1.5	6.5

Pre-school children were given a daily food supplement of green gram laddus

supplementary foods tended to become substitutes instead of supplementing the normal food intake of the children at their homes. In this programme, special precaution was taken to distribute the supplement at a time of the day which did not clash with the regular meal hours at home. The results of a diet survey conducted later confirmed that there was in fact no reduction in the home food intake of the experimental children.

After the programme had been in operation for 2 years, an evaluation study was carried out. The objective of this study was to assess the impact of this programme on the community. This evaluation sought to find out any changes in (*a*) the clinical incidence of PCM among the children; (*b*) their physical growth; and (*c*) the attitudes of the different members of the community.

Trained medical investigators examined the experimental and control children for the presence or absence of well-known clinical deficiency signs of PCM — hair changes, " moon-face ", swelling of the extremities (kwashiorkor) and emaciation of limbs (marasmus).

The table on page 31 shows that children who were given the supplement were nutritionally better off than those not included in the programme. Kwashiorkor, a severe form of PCM, was completely prevented among the children given the supplement.

A comparative study of the growth status too was made. The absolute figures for heights and weights showed higher values for children fed the supplement. But the differences were not statistically significant. This might have been due to the small number of children studied or the short duration of the study.

The results of a survey conducted to assess the community's attitude toward the programmes were revealing. The community, in general, had gained quite a satisfactory knowledge of the programme and its objectives. Comparatively, village leaders were more aware of it than parents, and mothers more informed than fathers.

Only 5 per cent of the members surveyed attributed untoward effects such as diarrhoea, fever or cough to this feeding programme. The rest reported better health and weight-gain in their children. Low socio-economic status, low literacy, non-availability of time and existence of cultural barriers were the main hindrances to community participation. This smallscale feeding programme under field conditions has shown an important and practicable means of protecting pre-school children from the ravages of PCM.

It proved that we need not depend on processed foods for fighting the problem of PCM. Locally available inexpensive foods could be usefully exploited to formulate recipes acceptable to the community. Another significant point that emerged was that proper motivation and education of the community about the objectives of the programme would result in active community participation. The major achievement was that the programme aroused active interest in the welfare of children. In the ultimate analysis, this awareness is the guarantee that the day-to-day nutritional needs of the children will be properly met.

V. Ramadas Murthy

(*National Institute of Nutrition, Hyderabad*)

BRAIN TEASERS

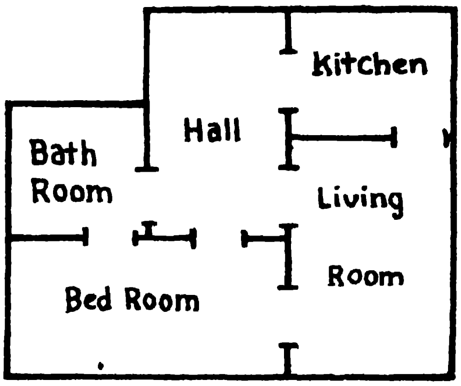
The big move-round

It was a very small flat, but at least it was their own.

" And here is a surprise for you," said Raj as he slipped the key into the lock and prepared to carry Rina over the threshold.

" I ordered the furniture last week and they moved it in yesterday."

But the surprise turned out to be not quite what he had intended. To their dismay, they found that the furniture-movers had put the dining-table in the kitchen, the kitchen unit in the hall, the bath in the living room and the bed in the bathroom.



And when the newly-weds came to moving things round, they found that the rooms were so small that no two of these pieces of furniture could be stood in the same room at the same time.

" Now don't let's rush it," said Rina. " For one thing, we don't want to go heaving the heavy bath from room to room more than is absolutely necessary.

" Let's sit down and try to work out the smallest number of moves it will need to get each thing into its proper room."

The page problem

The only thing in the waiting room was a pamphlet left behind by some other rail traveller, and since it was written in Hindi it offered little in the way of entertainment until I hit on the idea of adding up all the page numbers.

They at least seemed to be in English, so I started: " One and two make three, and three make six, and four make 10, and five make 15 . . ." and so on until I arrived at a final total of 90.

Then, since there was nothing else to do, I checked my additions, which turned out to be right, but when adding the numbers the second time I noticed someone had torn out from the pamphlet a leaf which, of course, would have borne two numbers I had not included in my addition.

How many pages were there in the pamphlet originally and which page numbers had been torn out?

The age-old question

I should have known better than to question three girls about their ages.

" Malathi is the youngest of us," declared Lakshmi.

" I am 21," explained Malathi.

" She is really only 20," put in Ambika.

" Well, Ambika is a year older than I am," added Malathi

" I am not the oldest of the three," said Ambika.

" Ambika is 22," volunteered Lakshmi.

" And Lakshmi is 24", snapped Ambika cattishly.

" It is true that there are two years separating Ambika and me," admitted Lakshmi.

" And Lakshmi is three years older than me," concluded Malathi.

As I have said, I should have known better than to question girls about their ages — it is a subject on which the fairer sex is traditionally granted a certain degree of latitude one way or the other as circumstances dictate.

Afterwards I did find out their true ages: their mothers told me!

On the whole, I suppose they had been about as truthful as one could hope for under the circumstances. Out of the nine statements they had made to me there were only three inaccuracies — one from each of the three girls.

What were their true ages?

Xeno

(*Answers next month*)

Solutions to last month's Brain Teasers

1. Satish and Rekha Sawant occupy the top flat. Ramesh and Anuradha Vohra occupy the middle flat. Robin and Sharmista Mukherjee occupy the ground floor flat.

This is the only combination which will account for all the ups and downs of the problem.

2. Six boys in Mr. Court's class (needing 15 matches if each boy is to play every other) and 5 in Mr. Ball's smaller class (requiring 10 matches).

TO SELECT A LEADER

HRAND SAXENIAN

Filling an empty executive's office is a task of central importance. Above all technical qualifications, the author proposes a criterion which 'relates to basic honesty with oneself and others and the psychological security to sustain, under pressure, concern for others while at the same time maintaining one's own [illegible] and convictions'

WHEN we consider what a good leader is worth — in a factory, on a construction crew, in a research laboratory, executive office, city or ship — and what a poor leader costs in money, accomplishment, material resources, human resources, human dignity — we see that the choice of a leader requires our best efforts, our most careful attention. So how should we set about finding and encouraging leaders, in all realms, who will wisely influence the development and uses of science and technology — leaders at all levels who will permit the individual to retain his identity as a person in a world which is organised on an ever larger scale, and in which so many decisions are based on narrow considerations?

" Self-made " leaders emerge in response to many forces, irrational as well as rational. Ability and experience are necessary, but sheer aggressiveness counts for much, as do chance, politics, discrimination and that grasp of circumstances we call opportunism. And, perhaps, it is true that sometimes, unexpectedly and unpredictably, the position makes the man.

But given the task of *selecting* a leader, we shall do well to stress what is rational and controllable. We begin, usually, by looking for " drive " and purpose, knowledge and experience. These are pretty much taken care of in the process of the individual finding his way through the routine machinery of a modern organisation. An engineer, scientist or architect expects of his supervisors and managers basic technical knowledge and mature technical judgement. Similar expectations are held of managers of financial institutions, art schools

---

Reproduced with permission from TECHNOLOGY REVIEW, Vol 72, No 7, May 1970. Drawings are by Milon Mukherjee.

and law firms. In all professions, the assessment of the technical competence and administrative skills of managers and executives is generally given the careful attention it requires.

The human qualities

Professional competence alone, however, does not make a leader — does not insure that a person will command respect, get results and point the direction in which his organisation (people, constituency) must move. For this we must look beyond specialised competence to personal maturity. We must somehow discern the relative abilities of men and women of purpose to use their technical competence in new situations; to work under greater pressures than they have encountered in the past; to inspire and support the best efforts of others — starting with their immediate subordinates; to see themselves and their organisations as part of a larger changing scene, which can be constructively influenced.

These are among the qualities of personal maturity to be discerned in a potential leader. Throughout history they have been prerequisites for good statesmanship and executive leadership and these qualities now become increasingly important — with the growth of scientific knowledge and the advance of technology — in those who would deploy the tremendous forces of man and nature.

These same qualities are not imperative at *all* levels, if strong organisations and free societies are to hold together amidst serious challenges to established customs and institutions. They characterise equally the effective foreman, research director, corporation president, minister, police sergeant or chief, army sergeant or general, school principal or superintendent, town or city manager. These qualities must be demanded alike of each: the differences are in the professional aptitudes and qualifications only.

These are human qualities, to be discerned by human beings — preferably, those most directly involved. They cannot be judged by a computer, nor even adequately by routine psychological tests or outside "experts". They are best judged within the context of the situation in which the leader must work, by those most directly responsible for the selection and for its consequences. For the difference that a person will make to a new situation will result from the organic interaction between himself and that situation. For example, the same person will perform differently under a different boss.

A " good " selection made by an outsider is never as good as the same selection made by the person directly in charge of the position being filled. Although this immediate boss might well be overruled by his senior on a given candidate, the final selection decision should still be his — just as his own appointment should have been the responsibility of *his* direct senior.

Since the discernment of maturity is largely a matter of judgement, and since our judgement is hardly infallible, it is well to bring the separate judgements of at least a few concerned people to bear on the decision. When done with care, this brings a useful degree of objectivity to an inherently subjective matter. A procedure designed for just this purpose is presented here.

The " expression " criterion

At the heart of this procedure is a fundamental guideline, which I have been investigating since 1952, to assist individual judgement in the assessment of a person's maturity:

" The current level of a man's maturity is indicated by the extent to which he expresses his own feelings and convictions with consideration for the thoughts and feelings of others."

Forthrightness, combined with awareness of and consideration for others, is essential for communicating and working with others as a leader. And increasingly, though often in too facile a way, we hear of the need for openness, sensitivity, trust. Let us consider this particular articulation and its potential usefulness.

At first, this criterion for maturity appears to many to be obvious, or oversimplified, or erroneous, or just another value judgement. On consideration, however, it usually takes on fuller and more definite meaning: it refers to a quality of expression beyond mere articulateness or tactfulness. It relates to basic honesty with oneself and others and the psychological security to sustain, under pressure, concern for others, while at the same time maintaining one's own position and convictions.

Originally an attempt to formulate something that, from my early selection experience during World War II and in industry, I felt to be an intuitive perception shared and unconsciously exercised by most people, this proposed criterion for maturity has since shown both a pragmatic and a theoretical validity. Most people who consider it find that it reflects their experiences with the people they have known and worked with over the years. In use, as a conscious guideline, they find that it serves to heighten their awareness of what to look for in a potential

INTERVIEW IMPRESSIONS OF
MANAGERIAL QUALIFICATIONS

[to supplement information on technical qualifications and record of performance]

NAME ....

√ **Individual impression**
☐ **Group impression**

	low	below	average	above	high
PHYSICAL IMPRESSION Appearance, bearing and manner	......	......	......	......	......
QUALITY OF RESPONSES Logic, judgement, clarity of thinking and expression	......	......	......	......	......
READINESS FOR MANAGERIAL RESPONSIBILITIES As evidenced by extent of expression of own feelings and convictions, with consideration for the thoughts and feelings of others	......	......	......	......	......
MANAGERIAL POTENTIAL Above factors combined, plus evidence of motivation and ability to increase his effectiveness with further experience	......	......	......	......	......

COMMENTS ....

INTERVIEWER ....

DATE ....

© Hrand Saxenian Associates 1968 Concord, Massachusetts

The Interview Impressions Form is designed to focus attention on the three basic questions underlying any careful final interview:

— Does the candidate seem to make good sense intellectually ?

— Does he seem emotionally ready for the pressures and responsibilities of the position to be filled ?

— What seems to be his motivation for the position and his future potential ?

Each of these questions still entails subjective judgements and there is no prescribed weighting of them. But at the point of decision — after screening on the basis of background, qualifications and past performance — there seems to be no substitute for carefully considered individual and group judgements on these three factors by those who must live with the decision.

leader, sharpening their perception of how well a person might handle new responsibilities.

This criterion is also supported by a small but growing body of basic research. In controlled tests of its validity, primarily among industrial, school and police supervisors and administrators, composite judgements based on it (with the abstract word "maturity" removed) have correlated highly with independent measures of "effectiveness", defined as "how effectively one works alone and with others while under pressure in a variety of circumstances".

The reader can informally test for himself the correlation between the "expression" criterion and "effectiveness", by ordering his impressions of the qualities, performances and lives of a few acquaintances and colleagues. Tests relating the criterion to personal effectiveness have been made in two ways. First, by noting how a person compares with others whose roles, authority and responsibilities are similar to his and second, by noting how his effectiveness has changed, for the better or the worse, over the years. These two ways of considering effective leadership would appear to include all practical cases in which we need and use a concept of human development such as "maturity".

The research to date suggests that " the extent to which one expresses his own feelings and convictions with consideration for the thoughts and feelings of others " is not simply one of any number of attributes of importance, but is by itself a key indicator of one's overall effectiveness. Besides proving useful in the selection process, this criterion has also helped in considering the whole question of positive leadership, including its early recognition and the establishment of management procedures which will encourage and facilitate its development. It accommodates wide diversity in individual personalities and styles of leadership and allows each person to make the most of his own natural style. There is an analogy here with learning a sport such as tennis, which seems to merit a brief digression.

> The qualities required of a leader cannot be judged by a computer, nor ever adequately measured by routine psychological tests or outside " experts "

In many sports there is a relationship between force and control which parallels the relationship in real life between self-expression and consideration for others. In tennis, for example, a player's game does not depend solely on how often or how hard he hits the ball, regardless of where it goes, nor conversely on his control alone. Nor is improving his game a matter of simply increasing one at the expense of the other. Force and control go hand in hand, increasing together with experience and stiffer opposition — alternating at times in their progress, but still rising together in the long run.

Expressing our true selves and considering the thoughts and feelings of others go hand in hand in a similar way. Only as we learn to express ourselves more honestly and clearly are we able, under increasingly demanding circumstances, to remain considerate of others. Analogies are provided also by quite different sports, such as boxing and swimming. Force and control must be coordinated and must improve together.

To extend the analogy: players have different styles and strategies, but we can appraise any player's game as a combination of force and control. Similarly, a single criterion for maturity, or overall personal effectiveness, can be applied to each of us despite differences between our individual styles and temperaments. Life is more complex than tennis, but how each of us lives his life depends on how he uses (or is permitted to use) the particular temperament he was born with — as a tennis player's game depends on how he uses his particular playing style.

A guide, not a measure

The " expression " criterion has been incorporated into the selection and promotional procedures of a growing number of organisations. In most cases it is used without any recorded ratings, but simply as a conscious guideline. Never easy to use, nor ever a substitute for thought, when used consciously it adds depth to what one looks for and induces more careful thought about what one observes. The very awareness of the criterion is helpful to many people entering into a selection situation as interviewers.

On a more structured basis, and in particular to meet the needs of larger organisations, this criterion for maturity is being used explicitly as an indicator of *readiness* for *responsibility*. The Interview Impressions Form shown on p. 36 — a simple tool in itself — is used according to a carefully worked out set of procedures, some key points from which follow:

1. Final candidates for appointment should be interviewed by three to four managers or supervisors, preferably from one level above the position to be filled and including the responsible manager who should make the final selection.
2. Interviews should preferably be conducted separately by each interviewer . . .
3. Each interviewer completes his form after the interview and prior to any discussion of the candidate.
4. The interviewers together discuss the candidate and their individual impressions of each factor on the form, arriving if possible at an agreed-upon rating for each factor . . .
5. Next each interviewer makes any final comment he wishes, or indicates any final difference of opinion he may have with the group ratings, signs his form and turns it over to the responsible manager, who combines this information with all other relevant information and arrives at his decision.
6. Once the decision is made, this form should be destroyed by the responsible manager. It has served its purpose as a working tool. Each new selection, promotion or transfer is best approached anew, encouraging a broad base of competition and recognising the possibility of significant changes in a person's current readiness of managerial responsibilities.

This process, designed for use at the *final* stages of selection, places the responsibility for selecting the management team clearly within the ranks of the existing team and does it in such a way that each immediate supervisor, manager, or executive selects his own man, yet with the benefit of the perceptions of others at his level of the organisation. (Though elementary in concept, seldom are these steps practised consistently and together. The total time required to interview and discuss, say, three or four final candidates may seem great, but it is really minimal in terms of the future implications for those directly involved and for the total organisation.)

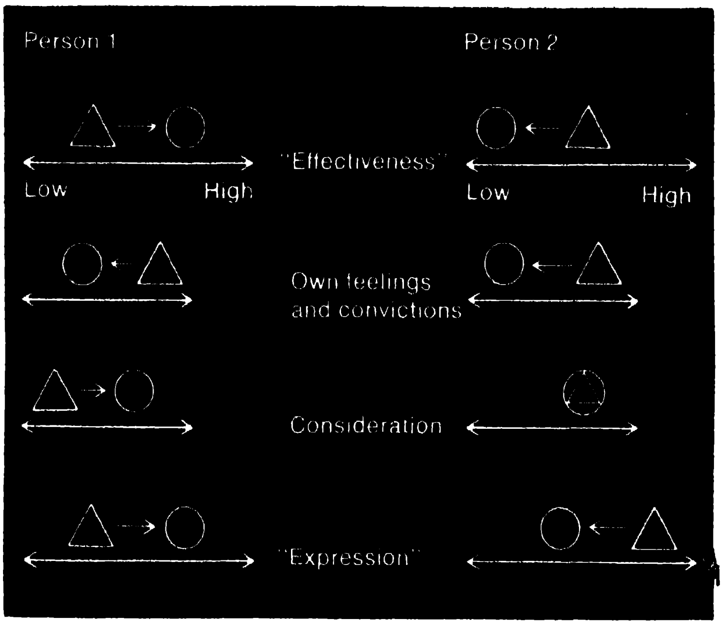
Keep it practical

The interviews need not be highly personal, but rather practical. Each member of the management team learns with practice (without elaborate rules or instructions) to exercise his own best judgement in each case on what questions to ask, how to ask them and how to listen to the responses. The required exchange of opinions helps him to refine his own interviewing approach. (The one strategy I would recommend is to give the candidate a full

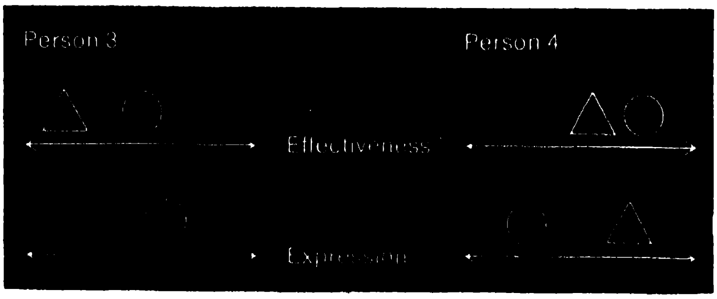
(. . . *to page 40*)

The criterion for leadership described by Mr. Saxenian on the previous pages has been tested in relation to the perceived and measured effectiveness of executives by the techniques outlined on these pages

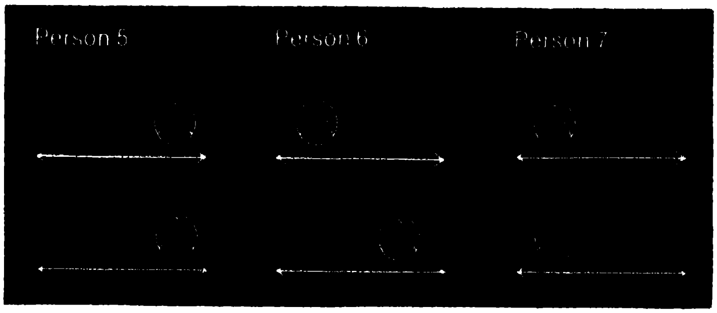
Hypothesis 1 supported



Hypothesis 1 refuted



No evidence for or against Hypothesis 1



Testing the criterion of maturity

Underlying the research on the validity of the criterion for maturity discussed here is the following hypothesis:

Expression, the extent to which a person expresses his own feelings and convictions, with consideration for the thoughts and feelings of others, indicates *effectiveness*, how effectively he works alone and with others while under pressure.

To permit operational testing, this has been resolved into two more specific forms:

Hypothesis 1:

Increases or decreases over periods of years in a person's *effectiveness* are accompanied by respective increases or decreases in his *expression.*

Hypothesis 2:

The relative *effectiveness* of people with similar activities and responsibilities corresponds to the relative level of their *expression.*

To obtain a feeling for how these two hypotheses can be tested, consider the following two sets of procedures.

Testing hypothesis 1

To test hypothesis 1 informally, recall a few people you have known reasonably well whose effectiveness or expression changed in your opinion over a period of years. They may be acquaintances of any age, from any walk of life. In each case, ask yourself if both effectiveness and expression changed in the same direction, for the better or the worse, over the period considered. If so, hypothesis 1 is supported by this case ; if not, hypothesis 1 is refuted by this case. (Reasons for the changes may be of interest and importance, but are incidental to the question here of the general validity of the hypothesis. Also, the magnitudes of the changes are not of direct relevance here, only the directions of the changes.)

Each case supporting or not supporting the hypothesis can be depicted as at the left.

Testing hypothesis 2

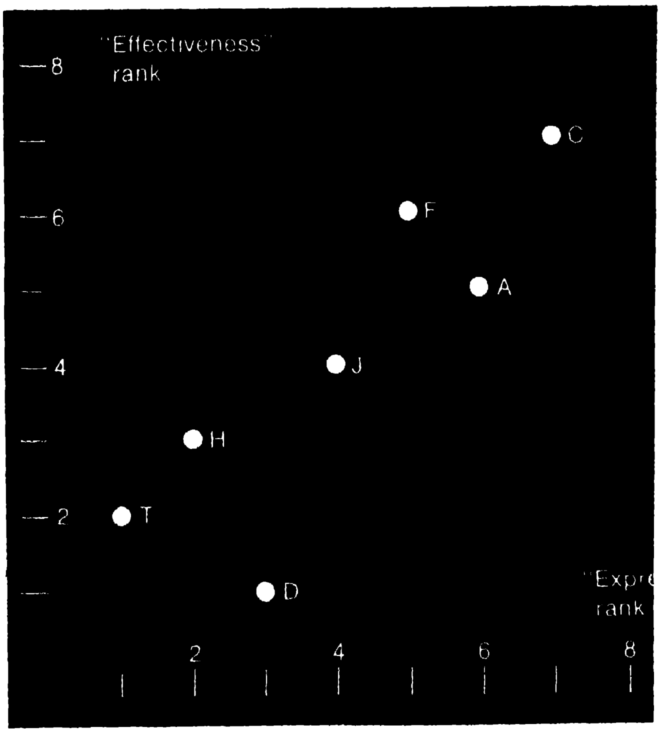
To test hypothesis 2 informally, call to mind a few groups of people you have known reasonably well with *similar* roles and responsibilities -- supervisors, managers, military officers, teachers, classmates, etc. For each such group, rank its members against each other on their effectiveness and then on their expression. The following is an example:

Visual comparison of the two ranking scales, or inspection of the pattern of points on the correlation chart, will give a rough indication of the extent to which any given group does, or does not, support hypothesis 2.

Rigorous testing requires two separate sets of observers, many subjects, many tests, control groups and conventional methods of statistical analysis. The above basic processes and modes of interpretation remain the same though, whatever more refined techniques may be used for rigorous testing of the two hypotheses.

This approach is quite general and can be used to test and compare alternative proposed criteria for personal effectiveness. Thus we can conceive of a competition of ideas — in quest of the best possible articulation, the most valid, understandable and useful criterion for overall personal effectiveness. Together with historical and biographical evidence, this approach might help us to understand better in a fundamental way the more complex concepts — the higher level abstractions — of maturity and leadership.

Effectiveness ranking		Expression ranking	
1.	Dick	1.	Tom
2.	Tom	2.	Harry
3.	Harry	3.	Dick
4.	Jim	4.	Jim
5.	Allan	5.	Frank
6.	Frank	6.	Allan
7.	Cary	7.	Cary
8.		8.	
9.		9.	



(*Contd. from p. 38*)

opportunity at the outset to say what is important to him and what he has to offer if selected and then to question him for consistency with his own philosophy.)

When, as is not infrequently the case, the man selected is the one who would have been chosen without this process, he and his new boss are still better off for having gone through the steps recommended here — as also are the other final candidates and managers participating in the decision. Often, when this process is used, some candidates are seriously considered who otherwise would not have been considered even at the outset. The increased opportunity for, and equity of, such consideration increases the chance of choosing correctly. The beneficial effect on performance and morale reach right down through the ranks of the management organisation to the labour and non-supervisory personnel.

While encouraging promotion from within, this same process is very helpful when a new manager or executive must come from outside the organisation. Potentially unwise selections are guarded against and a useful introduction to each other is provided the new man and the interviewing managers from a number of different departments.

The president of one large public utility company said of this selection process, " It irons out some of the tougher problems we have struggled with for a long time. We find it a practical way to broaden the base of competition for management positions . . . it increases incentive for effective management and for providing the best possible service to our customers." An initially skeptical senior police administrator and former Marine officer, with years of experience in the selection and promotion of men, said after his extensive participation in the underlying research, " This criterion gets at the heart of what all review boards look for when trying to size up the whole man". Many teams of interviewers have found that the continued use of the " expression " criterion leads to fuller concurrence of their separate impressions of candidates and to more accurate predictions of actual performance. And a number of them have expressed the opinion that this regular use of the criterion has constructively influenced their own management of men.

In a recent issue of *Technology Review* (July/August 1969, p. 50), John P. Eberhard, former Director of the Institute for Applied Technology of the National Bureau of Standards, made an appeal for man-centred standards in our increasingly complex technological society: " What an infinite capacity the human has to be a part of the process of measurement and how little our standards attempt to use this ability! " In this spirit, whether used formally or informally, this criterion for maturity can help us to make the most of the rational possibilities open to us when we would select a leader.

QUANTITY VS QUALITY

THE PAPER EXPLOSION

G. A. BOUTRY

It has been said that up to 80 per cent of all research papers published never should have been. Why is this?

There are, in fact, three different categories of scientists: those who seek order (the great theorists); those who seek to explain; and those who seek mastery (the applications men). It is among the explanation seekers — the fundamental researchers — that the quality versus quantity problem is greatest. Among the factors detrimentally affecting the quality of their research are: the sheer explosive increase in their numbers; the fact that increasingly a scientist's merits can only be judged by the volume, not the content, of his publications; and, in European laboratories, the slavish imitation of American work

THINGS become worn with use; this is even true for non-material things. The overused term loses its precision; the word on everyone's lips changes its meaning, becomes stale. So it is with the word ' research '. At the very time when the importance of what it refers to is reaching its peak, the word no longer conveys any meaning other than a vision of grandiose and unspecified miracles, performed by a secluded quasi-priestly caste.

This devaluation goes hand in hand with mythification. ' Research ' becomes a catchword, a magic incantation. The qualifying adjective ' scientific ' has been dropped. So many are ' doing research ' these days in every field that John feels called upon to affirm that the research he is doing is on a much higher level than that done by James: what he is engaged in is ' pioneering research '.

While this watering down is taking place, and this magic is being built up, the manpower engaged in scientific research, and the time and money devoted thereto, continually increase. Whenever any category of proposed expenditure amounts to anywhere near 1 per cent of the budget, there is always someone around who asks: ' Cui bono? What will we get out of this? What will be the return? ' Wherever research budgets are discussed, in international organisations, in countries, in industrial concerns, this voice in last few years has begun to make itself heard. Hesitant at first, it has quickly gained in assurance.

No one thinks of doubting the validity of the question it asks. On the other hand, there is scant agreement on how to answer it, and for good reason: this question, so simple, so apparently straightforward, becomes obscure as soon as one attempts to answer it, precisely because of that vagueness and aura of magic surrounding the word ' research ', both in the language and in the psychological make-up of statesmen, financiers, manufacturers and the man in the street.

The question has, in fact, already been answered a hundred times, but always by affirmation instead of demonstration, reference being made to the prestige attached to knowledge, to the simultaneous growth of our knowledge and our material comfort, if not of our intellectual well-being, to the widening of our intellectual horizons and to the impetus given to our conquest of nature.

How, in today's atmosphere of passionately held opinions about science, can we discuss properly the question of quality and quantity in scientific research?

In an attempt to do so, we shall first look to the research workers themselves. In a necessary digression, we shall try to find out from them the criteria of their work.

All scientific endeavour proceeds from a motivation; and by the use of means, it is directed towards

From IMPACT OF SCIENCE ON SOCIETY, Vol. XX. No. 3, 1970. Reproduced with the permission of UNESCO.

an aim. This triad of motivation, means and aim defines a rectangular matrix (Table 1) which we can use as our starting-point in seeking to classify (as we must) research activities.

In theory, the various elements of this table can be combined in all possible ways. In fact, some fundamental psychological factors permit only an extremely small number of combinations.

Let us treat first the motivations. It can, it seems to me, be maintained that they all have in common a certain emotive character. It is not on the basis of a purely logical reasoning process that one devotes oneself to research, but to satisfy a need. It is because of this half-hidden aspect of their motives that I can venture to classify scientific and technological researchers into three types, according to the aims deriving from their respective motivations: those who seek order, those who seek explanations and those who seek to act.

After being so critical of the terminology of others, it behoves one to be careful with one's own. That 'order' for which research workers of our first type strive is a certain harmony of the universe, and if they seek it, it is because they have already found it. They 'know' that it exists, and their reward, the fulfilment of their special dream, is the contemplative enjoyment of that order, as they have reconstituted it. It is understandable therefore that the man who researches for order is but little concerned with the mechanism which underlies or maintains that order, and not at all with furnishing an explanation of it to his disciples.

We can also surmise that in whatever epoch, in whatever social environment such a man may exist, he always has been, is today, and will remain alone—the few disciples who sometimes follow him more or less blindly, can be discounted. The man who seeks order is a rare individual; and it is even more rare that he succeeds in formulating the principle for which he seeks. Such successes number only one or two per century.

Do you want examples? I will take them from the realm of physics, simply because this is the one discipline of which I have some knowledge.

Matter, energy, space, time: the man who seeks order discovers harmonies between these unknowables. His weapon, his tools, are usually nothing more than meditation. The result of his efforts? A new principle, reduced to a single phrase which as a rule future developments merely confirm and generalise: Newton establishes the fundamental principle of dynamics, Carnot gives us the second law of thermodynamics, Einstein the principles of relativity — the physicists of tomorrow will no doubt place the principle of wave/particle duality of de Broglie and the exclusion principle of Pauli on the same plane. Newton had no pupils, Carnot spent his brief life in isolation, Einstein was the scandal of the physics community before acquiring a few disciples.

The psychological make-up of the man who searches for explanations is completely different. The quiet pleasure and contemplation just described do not appeal to him. His passion is dynamic and it is to describe what he is seeking that the journalists daily write of 'forcing nature to unveil her secrets' or 'extracting the secret of the atom' — romantic images based on the idea of struggle against hostile influences.

At the very well-springs of his consciousness, the man who seeks order is working, in reality, to transcend the bounds of his finite self. The man who seeks an explanation is seeking something quite different: he daily re-enacts the myth of Prometheus, who bent nature to his bidding. All methods of investigation serve his purpose: in former times, he operated in the realms of dogma and pure theory (Descartes being the last of these); today he begins and ends with experiment, acquiring en route a

Table 1 SCIENTIST CLASSIFICATION MATRIX

Element	**Type I characteristic**	**Type II characteristic**	**Type III characteristic**
Motivation	**Aesthetic satisfaction**	**Thirst for knowledge**	**Desire for mastery**
Means	**Meditation**	**Logic and experiment**	**Experiment**
Aim	**Order**	**Explanation**	**Application**

broadened view and new tools of investigation. The explanation man is a builder of mechanisms: he puts together and takes apart the cogs of his explanatory machinery; he undertakes verifying experiments; the conclusions drawn from them in turn engender other experiments, and so on ad infinitum.

Experimental standards and the precision of measurements become more rigorous with time, from Pascal's barometer to the deflection of light rays by a mass, from the crude to the limits of the measurable. Ever more precise, ever more delicate, the experiments which our research worker has to perform become more expensive each day. They require, in addition to increasingly complex and costly equipment, ever larger research teams composed of ever more highly specialised individuals.

What finally typifies explanatory research is that it is never completed, and never could be. Behind each veil lifted or torn away lies another which must be lifted or torn away in its turn. Consequently, and to return briefly to the language of our financial expert, every appropriation granted to those who are moved by the desire for knowledge will certainly result in another request for an appropriation larger than the first.

There remains a third kind of research worker. This time it is the myth of Daedalus that is evoked, evoked by those whose motivation is the will to mastery and whose delight is to build useful machines (' useful ' in this context describes everything which enables man to increase his dominion over nature). The Middle Ages forged a special word to describe him: the 'engeigneur', the constructor of engines—which is the common root of the English ' engineer ' and the French 'ingenieur'.

Clearly, he maintains a close and friendly relationship with the explanation man, whose theories, systems and explicatory mechanisms will continually suggest to him new applications. Occasionally we will even find people changing from one category to another: one of the explanation men faced with a distinctly inviting idea for an application will turn for a moment from his primary research to explore the application in question and demonstrate its possible value (witness Lawrence, who interrupted his study of particle accelerators to describe and patent a cathode oscillograph designed to reproduce colour images on television). However, we are referring here to isolated instances, much rarer than we are wont to imagine.

While research workers motivated by the desire for knowledge are usually enthusiastic over the discovery of new applications, it is only because these applications enhance the value of their explanatory theories. At bottom, they remain quite indifferent as to what effect the applications in question may have on mankind in general. On the other hand, those whom I have called ' engineers ' are not really interested in the validity of the explanations which the explanation men provide. This dichotomy, already apparent in the days of classical physics, has become very marked since theoretical physics has assumed a non-figurative character.

One historical example of this point is this: for all their efforts, the great nineteenth-century electricians, Ampere, Faraday and all those who worked with and followed them, did not succeed in constructing a good rotary machine to generate a direct current. The one who got there first with the dynamo, the joiner, Gramme, knew no more of theoretical physics than what was contained around 1870 in a secondary school text-book.

Low cost and high quality

Can we accept the classification of research workers which we have just sketched very quickly and in an outline form? If we do, then we can immediately surmise that the requirements of the three categories in regard to time and money will be very different.

Nothing is as cheap as research which seeks for order; it is the affair of a few isolated individuals, an adventure of thought and meditation. The special theory of relativity was elaborated by Einstein in 1905 in the leisure time left him by his modest duties at the Berne Patents Office over the previous three years. Like all other achievements of this kind, Einstein's masterpiece dedicated to Natural Philosophy, rather than to mankind or even to his ingenious colleagues who are motivated by the desire for mastery, cost nothing and earned nothing; the language of cost accountancy will never apply to such adventures of the intellect.

Some of my readers may here smell a paradox, asking whether it is a negligible contribution, the new light which the discovery of a new principle suddenly throws on physical theory or on biological processes. Certainly not, nor is this what I mean. My contention is that such discoveries of cosmic importance rarely suggest a new explanatory mechanism and never a hitherto unknown application; when, on the other hand, independent of them a new application comes to light, we are all amazed to discover that the possibility was always inherent in the principle.

An example? The basic proposition relating the energy of a body to its mass ($E = mc^2$) was proclaimed by Einstein in 1905. During the next

37 years a whole corpus of nuclear physics developed without anyone's proposing to try to achieve the conditions under which the destruction of matter would release a quantity of energy which could be used on a macroscopic scale. On the other hand, immediately after the discovery of nuclear fission it was easily demonstrated that the energy balance of the new phenomenon completely corroborated Einstein's equation.

In the same way, the principle of stimulated emission of energy had also been propounded by Einstein in the course of one of his studies on quantum electromagnetic radiation. It is obvious to us today that this proposition potentially entails the possibility of constructing those coherent light sources that we call lasers. But at the time no one understood this; and when the first laser emitted light in the Bell Telephone Laboratories, Einstein's note had been forgotten. Needless to say, it has been rediscovered since.

If there is nothing less costly than the discovery of a new principle of Natural Philosophy, there is also nothing so rare. In this realm of thought, we can say without fear of contradiction that there is hardly any risk of waste: the mediocre and the inadequate are quickly discouraged and erroneous propositions or trivial papers are rare.

The work of the ' engineers '

Consider now the behaviour of the ' engineers '. Admittedly, the activity of these men requires operating expenses and investments which are always on the increase; admittedly, their number has grown steadily over the last century. It does not follow, however, that the search for applications must absorb an ever-increasing percentage of the resources of the private and public organisations which support it. When it is well conducted — or rather, well administered — as is the case with most of the private industrial enterprises that own or subsidise a laboratory, the percentage of the total budget which goes into maintaining the laboratory normally remains relatively constant.

It follows that the ' engineers ', those who reenact the Daedalus myth, must be following a law which is no less demanding for being obvious: it is not enough that Icarus' wings should work; in addition, they must not come off in the heat of the Sun. In other words, it is not enough to make ' useful things ' — meaning articles for which there is a potential market, exploitable in a not-too-distant future — but they must be ' things which keep on working '. This is to say that research on them, on their design and use, must be continued to the point where one can be sure they will stand up to use and present no inherent possibility of accident, damage or serious breakdown. This does not lessen the necessity for subsequent development work, an activity quite distinct from research, which ascertains the conditions which must be fulfilled in order to achieve a satisfactory production at the lowest price.

In the task of administering applied research, competition has both a tonic and a depressant effect, exactly as it does in the field of commerce itself. Provided there are no mutual assistance contracts between companies, which are being concluded more and more frequently, the administrators are often led to accept, for reasons of prestige in the eyes of customers or a lag behind competitors, very costly redundancies and duplications. Usually this remains at a tolerable level. The US is certainly the nation which has furnished the best examples of administering research so as to ensure both financial returns and prestige advantages.

It happens with ever greater frequency that it is the State itself that subsidises and administers research inspired by the desire for mastery: the requirements of national defence today not only include weaponry and armaments in general, but have their extensions into almost the entirety of the physical sciences — and beyond. Originally, the State only commissioned and administered research on subjects which were known to be of no short-term commercial interest but which could have major implications for defence. As time went on, this concept has become much wider in certain countries, resulting in the State's becoming a sort of supreme administrator of research in broad fields with more or less likely short and long-term commercial possibilities.

We shall not pursue the discussion of this matter, despite its importance, since this would call for a much broader approach, bringing in the politics and sociology of each country concerned. Suffice it to say that this applied research administered by the State, which may be either very good or very bad, has in fact furnished some remarkable examples of efficiency and success. For example, the achievement of the first two lunar expeditions depended on the management and co-ordination of a particularly thorny and particularly delicate complex of applied research projects.

There is, of course, a pathology of applied research. Mediocrity and inefficiency are to be found in all industrial laboratories — and administrative authorities can lack vision and competence. These adverse factors will, as a rule, make themselves the more quickly felt the smaller the laboratory — down to a certain minimum size, which depends on the type of work done. Some laboratories have died from afflictions of this kind. However, it can be affirmed without fear of contradiction that applied research is getting on rather well, financially speaking, and that its average rate of return is acceptable.

Quality and quantity in explanatory research

It is when we turn to review expenditure on research undertaken in the name of what we have called the thirst for knowledge that we discover real reason for concern. No competent person who has given some thought to the matter could dream of denying the necessity and the importance of explanatory theories and consequently the value of all the efforts undertaken to perfect such theories and extend their scope. Whoever bases himself solely on the short-term or middle-term financial return must admit that applied research would quickly dry up if the development of physical theory did not come continuously or periodically to its aid. If, more broadly, we take into account the importance of the implications of explanatory research for social, intellectual and moral improvement, we draw the same conclusion, but strengthened.

There is general agreement, then, not to expect from such research a direct return, for it furnishes applied research with ideas and society with what I venture to call a ' directional return ', frequently serving to criticise and combat the harmful side-effects of applied research. This is currently the case in the anti-pollution campaign.

Thus explanatory research must be, and is in fact, everywhere esteemed and respected. Given this fact, how can we explain the almost permanent dissatisfaction of research workers of this type? Hardly a week passes that a scientist (very often an eminent one) does not warn his nation in dramatic terms of the mortal danger which menaces research in his field. Certainly, in many countries, each time a budget is voted there is talk of a financial squeeze, so it can be assumed that these jeremiads have a mainly preventive function, since in democratic states one must alert public opinion if one wishes to influence the government of the country. That being so, these wails, it must be said, are very often couched in foreboding terms and by their very style tend to imply that the extent of the national duty to subsidise — that is, the amount provided — can only be determined by those very ones who live off them.

One thing is certain, and is most significant: no one can direct or control this form of research, neither those who are involved in it (and are too deeply immersed to have a sufficiently wide and far-ranging overview) nor those in government, with their insufficient vision and lack of specialised knowledge. Explanatory research therefore proceeds in a rather haphazard manner, so that a physicist of the preceding generation was able to say, almost without smiling, that a research worker brings forth scientific papers as an apple tree does fruit, with no further concern for their fate. It is indeed for this reason — to aid in keeping abreast of and grasping all this material — that so many scientific congresses and meetings are organised: their primary function is to improve person-to-person contacts and communications.

If we also take into account that the number of such research workers grows at a rate nearly equal to that of the 'engineers', we can well appreciate that a pathology in this field is liable to have not insignificant repercussions which sooner or later could become disturbing.

Whether he likes it or not, this type of research worker is a workman, and 95 per cent, at least, of his group are on salary or wages. He has to conform to the rules governing promotion, and since there is no longer really anyone at the summit of the research hierarchy who can discern his merit — unless he makes spectacular discoveries — he is obliged to find an influential patron and to publish as much as possible, because it is the volume of his papers that matters more than what they contain.

Let us attempt to illustrate this with some figures. In 1922, the total population of the United States was 118 million. In 1966, it was nearly 197 million, so it had increased by two-thirds. The graph reproduced here (Fig. 1) shows the increase, from 1896 to 1966, in the volume of original papers printed in 13 journals of the American Institute of Physics, a body that publishes almost all the American scientific journals in the realm of physics which report research of the type we are considering here. What do we see? Between 1922 and 1966, the quantity of papers published in this field had multiplied just about 50 times, a rate of growth 30 times as great as that of the population which is the source of the scientists who wrote all this material.

Incomplete but reliable surveys suggest that on the average the quantity published per research worker did not greatly increase over the same period. What increased therefore, and by somewhere in the range between 2,500 and 5,000 per cent, was the number of research workers who published their work. Can such an expansion in an intellectually demanding profession have been achieved without lowering the 'average quality' of the research worker? Is selection as rigorous? Has the profession the same intellectual and moral standing as it had in 1922?

Nor is that all. In Figure 1, we may search in vain for outbursts following the dates of the great revolutions in modern physical theory: 1905, relativity; 1911, the triumph of the quantum theory; 1924, the birth of wave mechanics; 1928, the beginnings of the electronic theory of solids. None of these events is marked by any significant feature on the curve, the only thing clearly evident being a slowing down in the rate of publication caused by the Second World War. One could, it seems, almost lay down the rule that ' the variations in the volume published are independent of the merit of its content'— an outrageous proposition on which I shall not be so cruel as to comment.

I had reached this point when a friend who was reading over my shoulder suddenly took me forcibly to task: " You have just implied for the tenth time, but without actually saying so, that the quality of our research declines as its quantity increases. That is common knowledge; one can hear it everywhere; one even hears figures quoted: for example, it is claimed that 80 per cent of present-day papers represent useless or superfluous work. Your discretion smacks of hypocrisy."

Perhaps . . . the word ' quality ', especially when applied to an intellectual activity, denotes something which cannot be measured. Certainly there are grounds for believing that our technical explosion is beginning to be accompanied by a decline which has already gone a long way. How could it be otherwise? The staff of research laboratories is increasing faster, as we have seen, than the total number of qualified personnel available; the percentage of mediocrities who are devoting themselves to research must be increasing, too. Moreover, as I have pointed out, the research worker is now just a workman, the quality of whose work it is no longer possible to evaluate properly.

Under the circumstances we can understand the curious theorem which I propounded a while back:

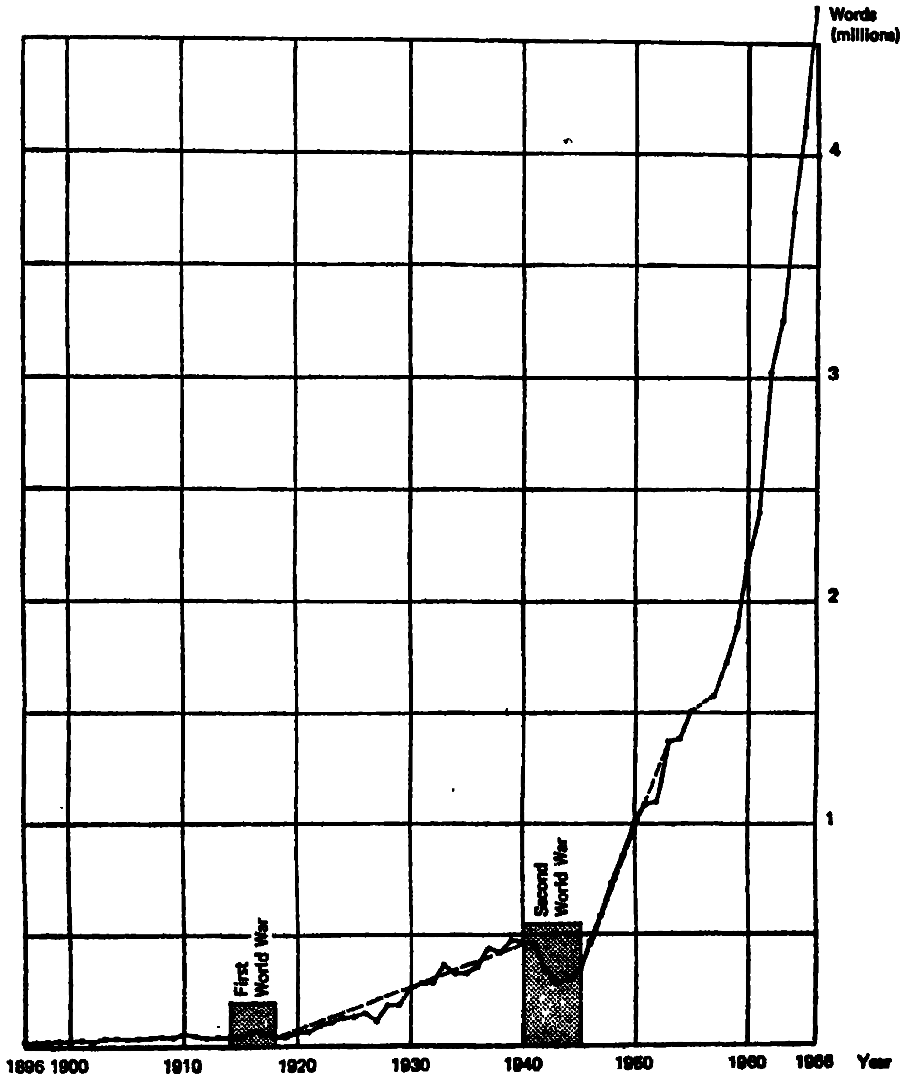


Fig. 1 Volume of original scientific papers and notes published in 13 journals of the American Institute of Physics (1896-1966)

that the volume published by researchers as a whole is likely to be decided not by what they have to report that is new and of value, but rather by the fact that they must publish something — it would be harsh to say, anything at all — at regular intervals.

If this be true, then we would expect to see scientific journals under threat of being flooded by low-quality papers. And, in fact, that appears to be the case, since these journals have set up systems of defence against such an inundation. Papers submitted for publication to virtually every journal are referred to one or more anonymous experts who can advise the editor-in-chief either to refuse the paper or to demand modifications or clarifications.

UNESCO has contributed to the purification of basic scientific journals and improvement of their quality by preparing a Code of Good Practice for Scientific Publications, which is distributed in six languages. Is this text, repeatedly approved at scientific meetings, followed by the majority of authors of papers? Forgive me if I doubt it.

In addition to the fact that many papers are erected, willy-nilly, on the foundation of a minor, mediocre and sometimes even negligible piece of research, there exists also an art of publishing without actually revealing the significant results that one has gained. The motivation for such conduct, which occurs not at all infrequently, is to be found in the conflict between having to publish as often as possible and the need to retain secrets for the benefit of certain industrial or military interests. Therefore, authors give an incomplete description of experimental procedures, or employ an obscure style, or state that the 'details will be revealed in a later paper', etc — there are a thousand ways of doing it so that 'you can have your cake and eat it too'. Piling proverb upon proverb, it is especially true of research that you must 'give all or not at all'. The distasteful procedure I have described would be judged by our forefathers to be unworthy of a noble man; but then nobility has long faded from the world scene.

I have already said that explanatory research cannot really be directed or controlled by anyone, it evolves in its own way. However, it has to be supplied with funds, and these funds have to be divided between various alternatives. What criteria are to be used for this purpose?

The replies which the developed countries have sought to give to this question vary; none of them is clear, none is simple. Many consist in entrusting this formidable task to a succession of committees and councils, each one further removed from the individual research worker than the last, and with their very acts so designed as to dilute and whittle away responsibility.

The frequent outcome of this is to cause European laboratories to follow in the trail of American laboratories: a research adviser or research director will see in the prudently varied imitation of work already done elsewhere an assurance — otherwise signally lacking — of positive results. Clearly a guiding principle of this kind leads to immense and costly duplication of work, which automatically results in lowered quality.

Finally, there is no longer competition between research teams but rivalry, which is something very different. I hope it will be clear that competition, in this sense, is productive of outstanding thought and work, whereas rivalry aims primarily at ensuring the success and survival of the most aggressive team. That atmosphere of youthful enthusiasm mingled with tranquillity which formerly characterised all laboratories, great and small, is gradually giving way to one of feverish bustle and sensation-mongering, and to the practice of issuing inappropriate and at times controversial press releases.

In addition, social agitation — that, too — has over the past several years become a feature of the laboratory scene. I referred a while back to the myth of Prometheus: well, our Prometheus of today is a wage-slave and defends his trade union rights. I don't reproach him but merely note the fact. But that there is a latent, widespread crisis within it is something the world of research is well aware of.

All this, as I replied to my friend, is doubtless very true and it all makes for a decline in the quality of our explanatory research. Yet it is all a matter of human imponderables. Nothing about it is quantitative or proved. Well-founded though they may appear, assertions and opinions do not constitute proofs — which is why I have remained cautious in my statements.

Quality and quantity in research . . . in this brief article I could only attempt to throw a faint light on a problem about which we have as yet no actual figures and whose effects on the development of our technological civilisation are not yet fully understood. I have tried to raise some questions, in imprecise terms to be sure, but in as objective a form as could be contrived. Only statistical studies together with the sound elaboration of a modern contemporary history of the development of science will perhaps make it possible to situate the problem correctly. We must hope so: the time is coming when the remedying of the wastage of time, material resources and thought will have to be done more successfully than it is today.

THE ANIMAL WORLD

OWLS

Large barred owlet

A MUTE shadow flits across the ground, overhead a ghostly bird sails silently against the starry sky. Suddenly it dives on an animal and soars off to its niche on a tree. The bird of the night has found its meal.

A constant companion of the magician Merlin (remember King Arthur?) and the Greek goddess Athene, it has long been associated with wisdom, maybe because of its sagacious looks and strange, nocturnal habits. Yet today the phrase " as wise as an owl " is used ironically to describe a dullard.

To the superstitious, the sight of the owl is anathema; many cringe at the sound of its hoots even. As with most superstitions, the " why " has been lost to time, but the belief still persists that the owl is a harbinger of misfortune or death.

There are 133 species of owls, most of which are nocturnal. They were originally classified as "raptores" with the other birds of prey like falcons, buzzards, vultures and eagles. Though in appearance they do resemble the raptores, structurally they are more closely related to the goat-suckers.

Ornithologists divide owls into two families, *Tytonidae* or barn owls and *Strigidae*, the true owls. Owls can be found in all parts of the world except the Antarctica and a few isolated oceanic islands. They come in varying sizes. The smallest, the elf owl of Mexico, is only about 13 cm in length whereas the great horned owls may reach up to 60 cm or more.

The physical characteristics are rather sharp in definition: large head, a well-defined facial disc and large eyes set forward and coloured unobtrusively. The bill is short and curved with the ends hidden in the bristles which form the facial disc. The barn owls have a heart-shaped facial disc and slightly longer legs feathered right up to the feet. Some owls have two upright tufts of feather on the head, commonly known as ears or horns (the scientific name is " aigrettes "). The feathers are soft and downy; this gives them a noiseless flight, a necessary requisite for a bird of prey that must catch its victims unawares; the silent wings also give it better hearing.

Owl eyes are adapted for dim light vision, but are also capable of functioning in bright light. It is not true that owls are blind by day. Their eyes are so large that they are crammed into the skull and are incapable of any movement, and to compensate, the neck is very flexible and can turn through 270°. They are the only birds endowed with binocular vision and long sightedness is another peculiarity.

If powerful sight is one asset for this hunter bird, the other major asset is its marvellous sense of hearing.

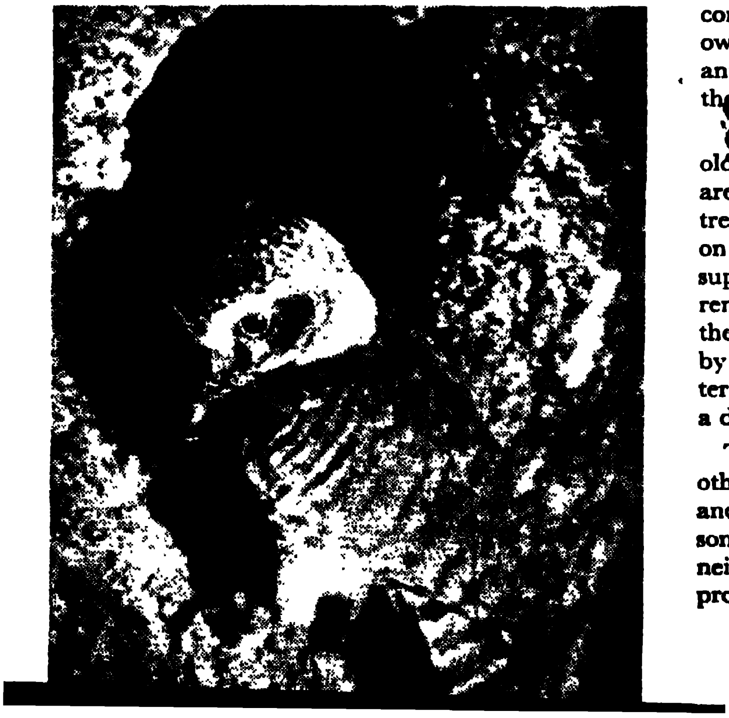
The owl's ears can catch high frequency sounds. The position and structure of the ears go a long way to locate the prey. Placed far apart on the sides of the head, one ear catches the sound slightly before the other, and this time lag indicates the direction of the sound. Again, the ears are placed asymmetrically, or are covered by asymmetrical flaps of skin, making the sound reach each ear by different paths, helping to judge the distance.

Experiments conducted by Roger Payne and William Drury have proved that the barn owl can strike a prey in absolute darkness. A mouse was let into a pitch dark room with dry leaves spread on the floor. The moment it moved, the owl swooped down and caught it. Of the 17 times the experiment was repeated, only 4 were near misses. But when one of its ears was plugged it failed. It is also suggested that plumes of the facial disc are sound-sensitive (as the strictly nocturnal owls have the most complete facial disc), but there is not yet any experimental proof for this.

The other adaptations for predatory life are its strong curved beak and reversible toe with automatic locking system to hold on to the prey.

Owls feed on small animals which they catch alive. The victims are carried to their nest or the favourite roost, and swallowed whole, or torn to smaller bits with the feet.

The undigested parts of the food are disgorged in the form of pellets. The type of food it eats can be judged by the contents of these pellets. Studies conducted in Britain and Poland have shown that the owl's diet consists mostly of rodents and other small animals; occasionally birds, fish and reptiles also join the menu.



Screech owl coming home with food

Eagle owl (European)

Owls do not build nests, but live in holes in trees, old buildings or discarded nests of other birds. The area around its home is guarded and kept free of trespassers. The size of the territory depends directly on the size of the bird and inversely on the food supply. Though a few owls are gregarious, they remain aloof at home. The nocturnal owls demarcate their territory by hooting; the diurnal birds do this by circling over the land. The great horned owl's territory is always separated from its neighbours by a distinct no man's land in between.

Though they defend their territories against others of their own species, birds of other species and animals often nest close to them. Strangely sometimes even their natural prey live in their neighbourhood and come within the fold of their protection. It used to be believed that instinct forbade

1

2

FLIGHT SECRETS OF THE OWL: 1. Level flight at full speed. 2. Note the bird's visual concentration as it gets under way. The unequal dilation of the pupils is probably caused by the dim secondary illumination at one side. 3. Lowering its landing gear and putting on its wing brakes, the owl prepares to alight on a branch. 4. The owl has landed with protective eyelids thrown down. This lid is a thick, transparent rubber-like membrane through which the owl can see. Its purpose is to protect the eye from branches and twigs when the bird is alighting after flight

killing near the nest but it is more likely that the prey animals adapt themselves to their enemies' habits. It may also be possible that since they are not on the look out for food when at nest, they ignore their prey.

The barn owl

Owls multiply slowly. The smaller ones breed when they are around a year old, and the bigger varieties mature late. Female birds are usually larger than the males. Eggs are few — 1 to 5 — and many breed only once a year. Compared to the songbirds, they have a long incubation period, about 35 days, during which the male feeds the female.

The young are born weak and helpless, covered with down. Two weeks later, this soft down is replaced by a fluffy mottled covering. The young are brooded for 4 to 7 weeks, and cannot fly till much later. All this time the parents feed them.

As a result of their hole-dwelling ancestry, owls are not used to exercising their wings; hence they leave the nest even before they learn to fly. On fluttering to the ground they struggle up trees using their beak like parrots do, but they never return to the nest. Even then they are fed by the parents. When

3

4

a baby owl strays into its neighbour's territory, the foster parents care for it, if food is abundant. The weak, disabled young and birds of abnormal colouration are killed.

Studies indicate that owls are monogamous, though dead mates are soon replaced. In the breeding season when demand for food is great, owls store all they can catch and the strictly nocturnal ones even venture into the day. Often lonely owls out in the day are mobbed by the crows and are quite helpless.

Ignorance and superstition had passed a death sentence on many of the owls. But it is now known that they do no harm whatsoever; instead they keep the rodent population and similar pests down. These birds with wise faces, which sit to breakfast at dusk and dinner at dawn, are certainly our friends notwithstanding their weird ways.

Sumati K. Sampemane

Screech owl quintuplets posing on the balcony of their tree house

QUIZ

HOW MUCH DO YOU KNOW ABOUT TEXTILES?

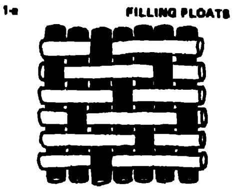
JOHN AND MOLLY DAUGHERTY

UNTIL the present century all fibres for textiles came from natural sources. As early as 3000 BC the Babylonians learned to spin and weave wool. The Chinese discovered silk around 2650 BC. There is evidence of the use of flax dating back 10,000 years. Both India and Egypt were centres of a cotton industry about 1500 BC.

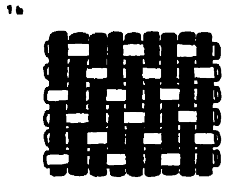
What do you know about textiles?

1. The basic weaves for fabrics are twill, plain and satin. Each has variations, too. Some other fabric weaves are pile, jacquard, dobby, double cloth and leno. Of course, some fabrics are not woven, for example, knitted and felted ones.

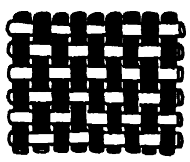
Which basic weave includes the largest groups of woven fabrics?



SATIN WEAVE



TWILL WEAVE



PLAIN WEAVE

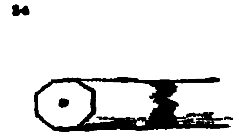
2. Most textile fibres absorb moisture from the air. The amount of moisture absorbed is standardised as a per cent gain of the weight of an oven-dried sample after exposure to a temperature of 21°C and 65 per cent relative humidity. Which takes up the greatest amount of moisture without feeling wet?

COTTON T SHIRT

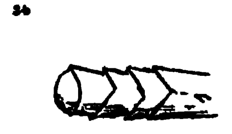
SILK BLOUSE

3. All man-made fibres are extruded as filaments of great length from the spinnerets. A cross-section of many filaments such as that of nylon, dacron and cuprammonium rayon shows a circular shape with a generally uniform diameter. Other shapes such as the dog bone or mushroom of the orlons are possible. The filaments may be reduced to staple — any cut fibres of a length expressed in centimetres. Among the natural fibres, silk is the only filament. The others are staple in lengths from about 2·5 to 42·5 cm.

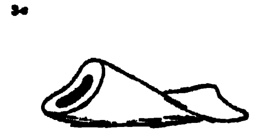
Of the common natural fibres shown below (cotton, flax and wool), which one is wool?



CROSS-SECTIONAL FIBER



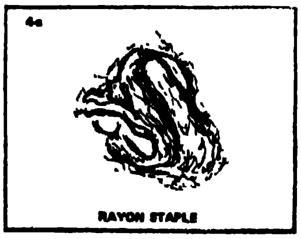
CROSS-SECTIONAL FIBER

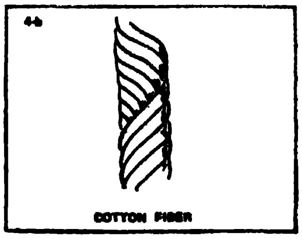


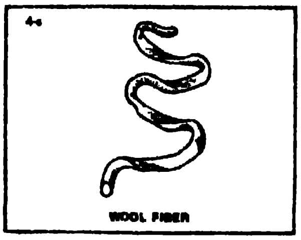
CROSS-SECTIONAL FIBER

4. The crimp in fibres is the waves or bends that occur along the fibre length. Most natural fibres possess crimp. and crimp may be added to man-made fibres by various means — mechanical, chemical and processing or finishing steps.

Which one of these has a three-dimensional crimp?

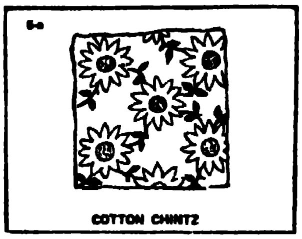
4a

RAYON STAPLE

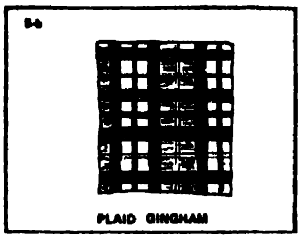
4b

COTTON FIBER

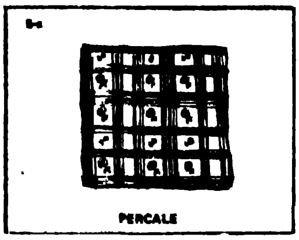
4c

WOOL FIBER

5. The colour and pattern of many cotton fabrics are printed on the fabric after it is being woven. In at least two fabrics, the yarns are dyed in as many different colours as are required for the design before aving.

Which is the yarn-dyed fabric?

5a

COTTON CHINTZ

5b

PLAID GINGHAM

5c

PERCALE

Answers:

1 — c. Plain weaves. Plain weave has a checkerboard design. The warp (lengthwise) yarn is woven with the filling (side-to-side) yarn. The plain weave accounts for about 80 per cent of all woven textiles. It is sometimes called tabby or taffeta weave and often cotton weave because so many important cotton cloths are woven this way. Cotton cloths include chintz, broadcloth, muslin, cambric, canvas, flannelette and others. The plain weave is used as well for other fibres such as wool, linen, acetate, rayon and man-made synthetics. (Acetate and rayon are made from the cellulose of plants.)

In **1 — a,** the filling floats on the other side of the usual warp surface of the satin weave. Here the ratio of four to one applies.

In **1 — b,** the twill weave in this example shows the filling yarn goes under one warp yarn, over two and then under one and over two. The next row shifts to the right so that the finished surface shows a diagonal warp line. The ratios of filling to warp yarn go as high as four to one.

2 — a. Wool. Its moisture regain is about 15 per cent, varying from 13 to 18 per cent, at 21°C and 65 per cent relative humidity. A wool buyer would be paying wool prices for water if the humidity went up to 90 per cent, for then the moisture regain rises to nearly 30 per cent by weight. With their high moisture content, woollen garments feel comfortable — not wet — to you.

In **2 — b,** cotton, also comfortable to wear, has a moisture regain of 7 to 11 per cent. Some synthetics feel clammy to you because of their low moisture regain.

In **2 — c,** silk has a moisture regain of 10 or 11 per cent.

3 — b. Wool in cross-section is nearly circular. Overlapping fish-like scales along the length of the fibre from root end to tip is its outstanding characteristic. For fine wools, the fibre lengths range from 2·5 to about 30 cm. Merino, the best of the sheep wools, has fibre lengths ranging from 2·5 to 12·5 cm.

In **3 — a,** the cross-section of the flax fibre is polygonal with nodes along the length of the fibre. Flax is the source of linen yarns. Long staple linen fibres range from 75 to 125 cm.

In **3 — c,** cotton fibres are relatively short. They range from about 3·75 to 6·25 cm for long staple cotton.

4 — c. Wool. Its crimp is three-dimensional. Wool is the most elastic of the natural fibres and can be stretched greatly before reaching the breaking point. It stretches as much as 25 to 30 per cent of its length.

In **4 — a,** rayon staple made from the same viscose solution as for spinning filament can be given a permanent crimp. The product from a

(Contd. on page 54)

QUESTION & ANSWER

What is the 'Coriolis effect'?

IF an object is stationary or is moving at a constant velocity relative to some fixed point, then there is no problem in moving across that object. If you wish to travel from point *A* at one edge to point *B* at the other in a straight line, then you can do so without feeling any difficulty in the process.

If, however, different parts of an object are moving at different velocities, the situation is quite otherwise. Consider a merry-go-round, or any large flat object rotating about its centre. The entire object rotates in one piece, but a point near the centre marks out a small circle and is moving slowly, while a point near the outer edge marks out a large circle and is therefore moving rapidly.

Suppose you are at a point near the centre and wish to walk out toward a point near the outer edge in a straight line directly away from the centre. At your starting point near the centre you partake of the velocity of that point and are moving slowly. As you move outward, however, the effect of inertia is to keep you moving slowly, but the ground under your feet is moving faster and faster, the further you step outward. The combination of your slowness and the ground's fastness causes you to feel pushed in the direction opposite the motion of rotation. If the merry-go-round is moving in a counter-clockwise direction, you find your pathway curving more and more sharply clockwise as you move outward.

If you start at a point near the outer edge and move inward, you retain the fast motion of your starting point but the ground under you is moving more and more slowly. You feel yourself pushed, therefore, farther and farther in the direction of the rotation. If the merry-go-round is moving in a counter-clockwise direction, you are again curving more and more sharply clockwise.

If you start at a point near the centre, move to a point near the outer edge, then back to a point near the centre, and follow the path of least resistance, you will find that you have taken a roughly circular path.

This phenomenon was first studied in detail in 1835, by a French physicist, Gaspard Gustave de Coriolis, and it is called the Coriolis effect as a result. Sometimes it is called the Coriolis force but it is not really a force; it is simply the result of inertia.

The most important consequence of the Coriolis effect in everyday affairs involves the rotating Earth. A point on the surface of the Earth at the equator sweeps out a large circle in 24 hours and therefore moves quickly. The farther north (or south) we go from the equator, the smaller the circle swept out by a surface-point in one day and the more slowly it moves.

A wind, or an ocean current, heading northward from the tropics, is moving very rapidly from west to east, with the Earth's rotation, to begin with. As it travels northward, it maintains its velocity, but the Earth's surface is moving at a less and less rapid rate, so that the wind or the current outraces it and begins to curve toward the east more and more. In the end, winds and currents (even dish water down a drain) move in large circles—clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere.

It is the Coriolis effect which starts the curving motion that, when concentrated more tightly (and therefore more energetically) becomes a hurricane, or, still more tightly and energetically, a tornado.

Isaac Asimov

QUIZ . . . *(Contd. from page 53)*

hundred spinnerets with about a thousand holes is collected into a large rope (filament tow). While still wet, the fibres are cut, and when the tensions from spinning are released, the fibres shrink. This gives a permanent crimp.

In **4 — b,** the cotton has a two-dimensional twist called convolutions giving cotton its crimp.

5 — b. Plaid gingham. Weaving gingham with previously dyed yarns results in a fabric that looks alike on both sides. The pattern of colours cannot be worn off by abrasion. Chambray is another yarn-dyed fabric.

In **5 — a,** chintz is a printed fabric which has a glazed finish.

In **5 — c,** percale may be printed on grain, which refers to the direction of the warp face of the fabric. It may be printed off-grain, too, which appears as a bias at the edge of the fabric.

Score Yourself:

4 — 5 right. No one can pull the wool over your eyes!

2 — 3 right. Your score has a crimp.

0 — 1 right. You don't cotton up to textiles.

FOR YOUNG READERS

THE RIDDLE OF PALEOGEOGRAPHY

SOME people claim the Earth has a history and throughout her history she has seen many changes on her surface. As an example they commonly put forward the case of the Himalayas and assert that there was a great ocean in place of the Himalayas only 150 million years back. These people were tortured by the Church for their blasphemous ideas even a few centuries back, until their science, the science of paleogeography, acquired a more sound foundation.

Most of the paleogeographical changes that took place in course of the Earth's history were as imperceptible as those taking place today. Thus, the filling up of an ocean is spread over a period of tens of millions of years, relative to which the span of human history is no more significant than a moment. The action of agents like rivers, rain water, glaciers or winds, which slowly mould the surface of the Earth, sometimes leave subtle evidences for posterity to interpret.

As a chemist sees the material universe in terms of atoms and molecules, a geologist sees it through minerals and rocks. The word "rock" includes everything which is solid and has been produced naturally by inorganic processes. Thus clay, sand, granite, marble and even ice on high mountains are rocks. There are three types of rocks — igneous, metamorphic and sedimentary. The last holds the paleogeographer's interest. They are formed, in general, on the surface of the Earth at surface temperature and pressure. The sand and silt which are being discharged by the Narmada river into the Arabian Sea, in course of time may get consolidated by the precipitation of chemical compounds like silica, calcium carbonate, iron oxide, etc in their intergranular spaces to form a sedimentary rock called sandstone or siltstone. It is in such sedimentary rocks that the key to the past geography remains hidden, and a paleogeographer (a geologist having special experience in interpreting paleogeography) with his logic and experience can interpret the paleogeography of a particular time.

Sand, which is acquired by a river along its course through the country, is deposited wherever the velocity of the river decreases. A river has higher gradients and consequently higher velocities at its upper course, and toward its mouth both of these gradually decrease. As a result, the size of the sand particles decreases gradually from the source of a river toward its mouth. So, in a sandstone layer, by analysing the grain size of samples taken at regular intervals, the current direction can be determined.

The current direction, however, may also be found from other evidence. A common feature of sedimentary rocks like sandstone is that they contain "ripple marks". The name itself is suggestive of and implies a series of ridges and furrows on a layer of sandstone, much like ripples on the surface of a pond. They may be symmetrical or asymmetrical. The latter ones are produced under the action of a steady current. It is known from experimental observations that the gently inclined side of the ridges face the current.

Both the above features are intimately connected with the ability of a river to move materials like sand or silt. In much larger bodies of water — the oceans or seas — though there are currents, they are not very effective in moving materials lying at the bottom.

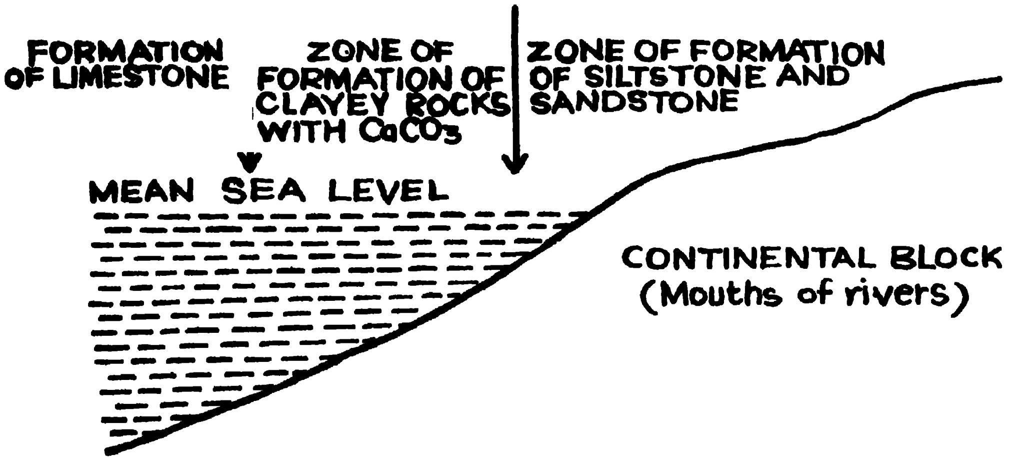

FORMATION OF LIMESTONE
ZONE OF FORMATION OF CLAYEY ROCKS WITH CaCO3
ZONE OF FORMATION OF SILTSTONE AND SANDSTONE
MEAN SEA LEVEL
CONTINENTAL BLOCK
(Mouths of rivers)

Fig. 1 Deposition of chemical sediments like calcium carbonate takes place at great depth, while sand and silt are deposited near the shore. No absolute value of the depth, however, can be given because presence or absence of sediments depends on the degree of disturbance of sea water and several other factors

For sediments deposited on the sea-floor, different features are available.

It is known that the depth of a sea or an ocean gradually increases toward the central part. Sea water, at the surface, contains dissolved oxygen and as one goes deeper, the oxygen content decreases. Sea water contains a large number of elements in solution. Depending on the depth of the sea bottom and the temperature existent for a particular volume of sea water, conditions suitable for the precipitation of different chemical compounds of these elements are met with. For example, at a great depth, precipitation of calcium carbonate takes place, which consolidates later to form thick beds of light coloured limestone. At less depth, precipitation of calcium carbonate takes place, with some clay, to form dark coloured clayey limestone. And near the shore there is no calcium carbonate, only silt or fine sand which may form siltstone or sandstone. So, the presence of a thick bed of light coloured limestone at a place implies the existence of a deep sea basin in that area. Moreover, where there is no disturbance, a layer of light-coloured limestone has an adjacent layer of clayey limestone followed by a layer of sandstone.

On land, however, the evidence left are not many in number and not very convincing. This is because on the land we do not get depositions. On the contrary, materials are continuously washed out from land thus eradicating even past evidence. There are a few exceptions. Deserts and dry lands, where winds play the role of the transporting agent instead of water, are also places of deposition. The principle of deposition is the same i.e. when the velocity of wind falls, deposition takes place. As winds cannot carry coarse materials, wind-borne deposits have the finest materials. There are features like ripple marks in these deposits also, and they are more perfect than those formed by water.

Deserts near seas contain a layer of sodium chloride (common salt) together with some soluble salts like calcium sulphate on the surface. After consolidation, they are sometimes preserved in the form of a layer of salt or gypsum which suggests dry land on the seashore.

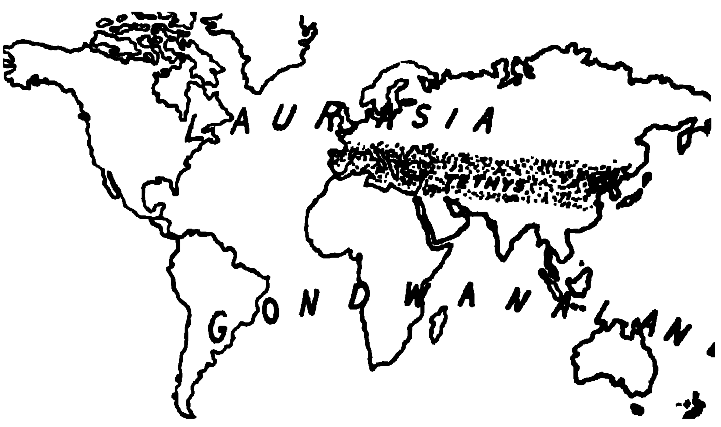
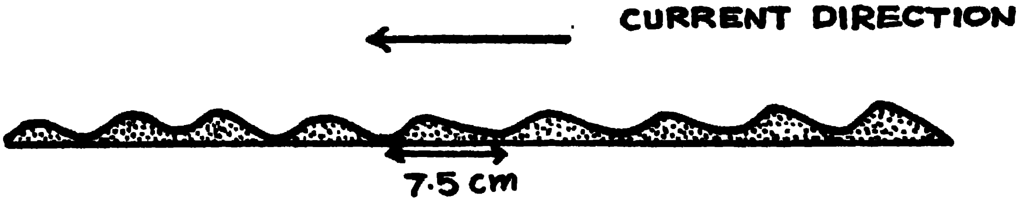


Fig. 3 A sketch map of the present day land masses showing the inferred positions of the old supercontinents, Laurasia and Gondwanaland, with intervening Tethys. While studying the evidence from which Gondwanaland and Laurasia were inferred, it seemed that the modern continents formed a nearly continuous land mass without the Atlantic or the Indian Ocean. Though scientists inferred a disintegration of the supercontinents and drifting apart of their constituents to acquire the present configuration, no satisfactory explanation could be forwarded for this drift.

Paleogeographers, like geographers, are concerned with accounting for the climate of an area. The evidence of paleoclimate, like paleogeography, are mostly sought in sedimentary rocks. Like ripple marks, there are some other features from which paleoclimate is " read " directly. A common example is provided by the " mud crack ". In areas where there is seasonal rainfall, shallow bodies of water dry up in summer. The clay at the bottom of a pond gets dried and shrinkage cracks develop. This observation has helped to interpret the similar cracks occasionally present in sedimentary rocks as the beginning of a dry spell.

The climatic condition is better reflected in the type of cement filling up the space between the grains in a rock like sandstone. Iron gets precipitated as hydroxide in an alkaline condition and on drying up changes to ferric oxide. So, the presence of iron

Fig. 2 The section perpendicular to the surface in the figure below shows the asymmetric nature of the ripples



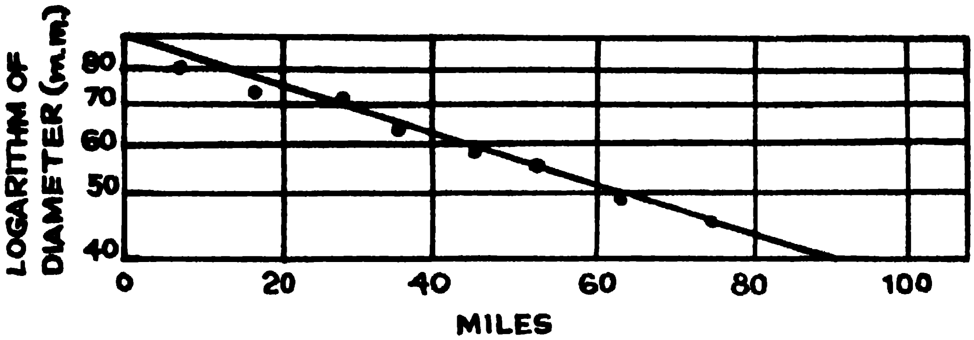


Fig. 4 The decrease in size of grains with distance downstream was repeatedly verified several times. The graph here was obtained for River Mur by Hochenburger in 1886

oxide cement indicates deposition in a tropical area with rather scanty rainfall. If the cement is mainly silica, the area is taken to have a humid tropical climate.

There are a few minerals, like feldspars, which have a tendency to react with the atmospheric moisture in tropical climates. As a result of this reaction they change their chemical composition and form a clay mineral, kaolinite, which is the common constituent of the china clay used in the ceramic industry. This process of transformation is known as " kaolinisation ". In temperate climates the degree of kaolinisation is low while in arctic climates it is zero. So the presence of undecomposed feldspar grains suggests an arctic climate. As both humidity and temperature are responsible for kaolinisation, extreme dry climates, like desert climates, can also preserve undecomposed feldspars. So, other confirming evidence are required to conclude whether the condition is desertic or arctic. Evidence similar to that indicated earlier helped find a period of extensive glaciation about 200 million years back. The Gondwana glaciation was further confirmed by the presence of typical plants of arctic climates.

Though life has existed on Earth only for a small fraction of her history, fossils, which are remains of extinct animals, indicate a good deal about the paleogeography. We know that arctic animals have some anatomical differences from those of tropical regions. For example, they have thicker layers of fat under their hides. Zoologists ascertain minute anatomical differences between animals living in different environments and ascribe them to climatic variations. On the basis of fossils of certain marine animals like corals, it is possible to estimate the depth of the sea where a particular sediment was precipitated.

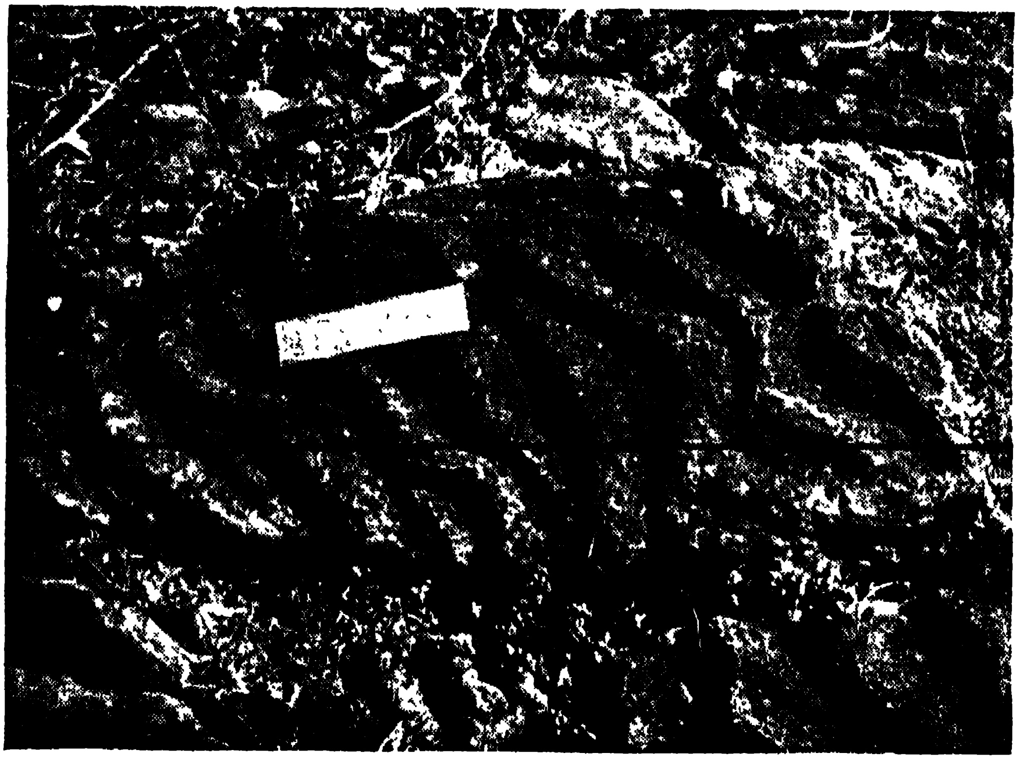


Fig. 5 Asymmetrical ripple marks are produced in shallow water or land under the action of a steady current of water or wind. The side with a gentler slope, preserved in the sedimentary rock, serves as a valuable guide to the direction of paleocurrent

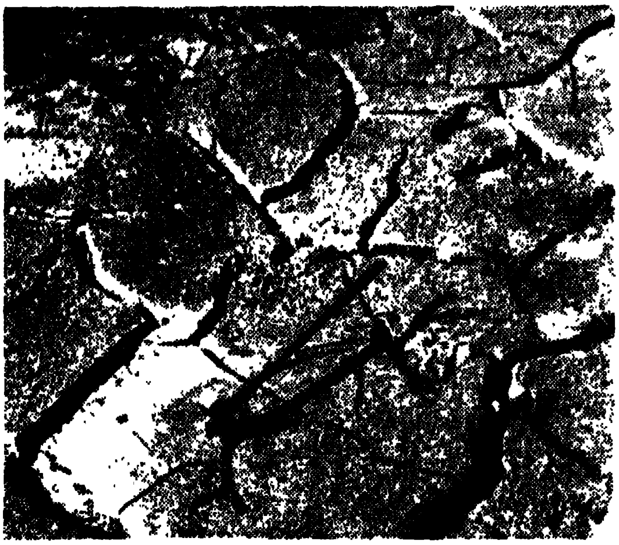


Fig. 6 Shrinkage cracks develop in the mud on the bottom of ponds during summer after the water has dried up. Further desiccation obliterates the cracks when fine dust forms out of mud. So the presence of 'mud cracks' preserved in sedimentary rocks indicates the beginning of a dry spell

It is thus possible to get some idea about the past geography of a region. However, there are certain limitations to these deductions. Layers of any sedimentary rocks from which paleogeographic data are to be drawn are supposed to contain all the necessary information. They do not always contain the information. Normally a sedimentary rock exposed on the Earth's surface should not contain fossils, ripple marks, etc which, whenever present, are present by way of accident. Obviously, a small fraction of these features are present in a sediment. As a result, patches of sedimentary rocks, the greater part of which has been washed out by erosion, very often yield confusing results. The exact limit of a prehistoric sea or ocean also cannot be determined. Thus, the presence of seashells in the rocks of the Himalayas indicated its rise from the ocean bottom. It could be concluded that a vast ocean was present extending from the east coast of Asia to the west coast of Europe, situated south of Siberia and north of the Deccan, but the exact position of its coastline could never be located.

Dipankar Lahiri

some people think we go too far.

we agree.

We are fastidious... about the quality of our products.

We know that for all exacting work there's no substitute for accuracy.

So there can be no compromise on quality.

Yes, we admit we are very particular.
Perhaps that's the secret of our success!

Quality Laboratory
Chemicals by

Sarabhai M. Chemicals Ltd.
Wadi Wadi, Baroda.

Shilpi SM 14/70

BOOKS

Geology of the Moon by Thomas A. Mutch (Princeton University Press, Princeton, New Jersey, 1970).

THE Moon has existed as an object of wonder and enquiry from time immemorial. But it is the landing of man on the Moon that has enhanced the interest not only of laymen but of scientists specialised in many diverse fields. Once the Moon was the preoccupation solely of astronomers and perhaps of poets. Today, scientists from such varied fields of research as cosmochemistry, astrogeology and exo-biology have turned their minds to the Moon.

This timely book, *Geology of the Moon*, tells us in a pleasantly readable style all that one needs to know about the surface features of the Moon in what is called a stratigraphic view. The major part of the informations are on the well-known surface features, the majority of which are the craters. Properties of impact craters as distinguished from volcanic craters are described and certain identifiable examples are given for both types.

All the theories and hypotheses on the lunar features are very well illustrated by clear photographs. It contains exhaustive analyses of basin, volcanic, crater and highland stratigraphy and other features like rilles, ridges and domes. At every stage, as the author writes in the introductory chapter, analogies to features on the Earth are given. This actually helps even a non-geologist in learning terrestrial geology.

Magnificent photographs of almost all the major craters on the lunar surface are given with details that leave little for the imagination. Most of the discussions are based on photographs taken by the Ranger, Surveyor and Apollo missions. However, the importance of telescopic work is also illustrated wherever necessary. One also wonders at the multitude of work based on earlier astronomical principles such as polarisation and intensity variations, though they lead to much less certain conclusions.

A chapter on the age of lunar surface features deals with a time stratigraphy and a sequence of time period based on crater ages. A final chapter on the Apollo 11 results convinces us of the accuracy and usefulness of the earlier unmanned probes of the lunar surface by the Surveyor and Ranger missions.

The book has no bias to any existent theory. It presents all the facts and weighs them in the light of current theories. It contains an exhaustive list of references on all the aspects mentioned and also includes an index map of the Moon. Since as the author states, " Unless the reader recognises these special definitions, he can read a stratigraphic article with superficial understanding but still lack appreciation for the rigorous development of the subject . . .", a glossary of terms, which are innumerable in number, would have added to the value of this book.

A remark on the Fig. X-b: In the text, on page 267, it is mentioned that " . . . the two lines labelled *a* and *b* define crater distributions . . . by a factor of 10 ". There are no such labellings on any of the six lines which are found in the figure.

Geology to some extent, like archaeology, deals with inferences based on observations, most of which cannot be tested in a laboratory. This is true of the geology of the Earth for which more data and a greater proximity of observations exist. Even so, many of the problems in terrestrial geology are inconclusive. In the case of the geology of the Moon — " selenology " as it is called — the problems are more difficult. Yet this book proves that a lot may be understood even from distant observations.

V. S. Venkatavaradan

[V. S. Venkatavaradan is with the Geophysics Group at the Tata Institute of Fundamental Research, Bombay.]

Electric Motor Control by Walter N. Alerich (D. B. Taraporevala Sons & Co Pvt Ltd, Bombay, Rs. 6·54).

THE electric motor is so much in use today that people tend to overlook its significance. This book provides some very detailed and valuable information on the common types of electric motors and the application of electric motor starters and controllers. It is divided into different units with each unit having a set of guide problems and questions to foster a better understanding of the subject. As the preface says, the text includes the tested experiences of the author and other craftsmen and follows sound educational principles, thus making it more than a mere standard text book.

Machine Technology (4 volumes) Edited by William G. Dickson (D. B. Taraporevala Sons & Co Pvt Ltd, Bombay, Rs. 21·60).

Machine Technology is a study guide and a workbook. The four volumes will be especially useful to machinist trainees learning to operate machine and production tools, perform bench and assembly operations and use precision tools and instruments correctly. Other related information — on interpretation of blueprints, the use of basic mathematics, etc — is also included in these volumes.

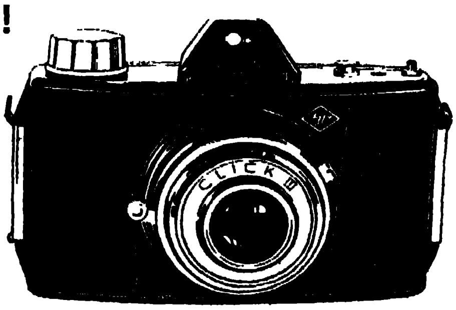
R.R.

PHOTOGRAPHY IS FUN WITH AGFA CLICK III

best to start with, best to stay with!

* Easy to handle. Needs no adjustments
* 12 large (6x6 cm) pictures on every 120 roll
* Ever-ready case, portrait lens and flashgun available at extra cost

For sparkling prints and enlargements insist on Agfa Photo Papers

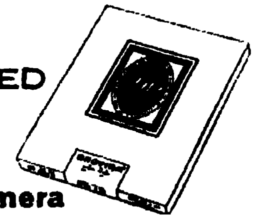


Rs.46.50 (Taxes extra)

**Available at all authorised Agfa dealers.
Made in collaboration with Agfa-Gevaert by:
The New India Industries Ltd., Baroda**

AGI

Sole Distributors:
AGFA-GEVAERT INDIA LIMITED
Bombay • New Delhi • Calcutta • Madras



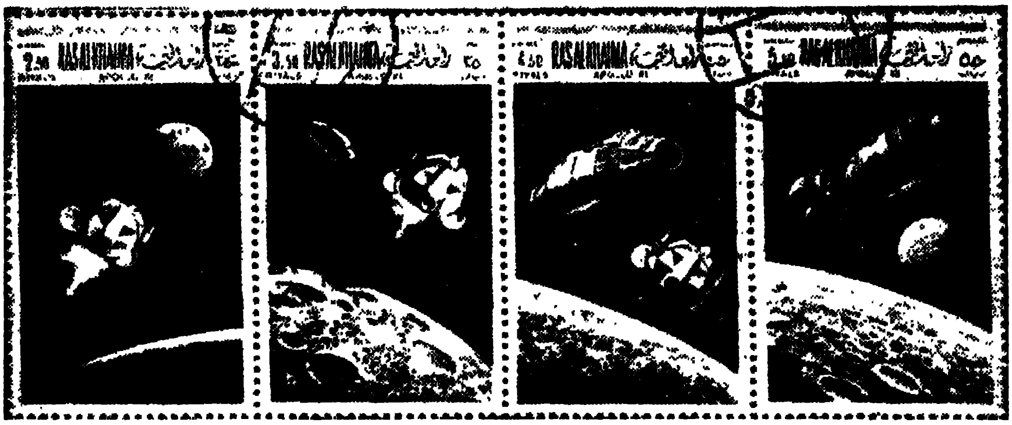
AGFA CLICK—India's most popular camera

Ⓡ **Registered Trademark of Agfa-Gevaert Antwerp—Leverkusen. Manufacturers of Photographic Products.**

CMAG-139-203 R

SCIENCE ON STAMPS

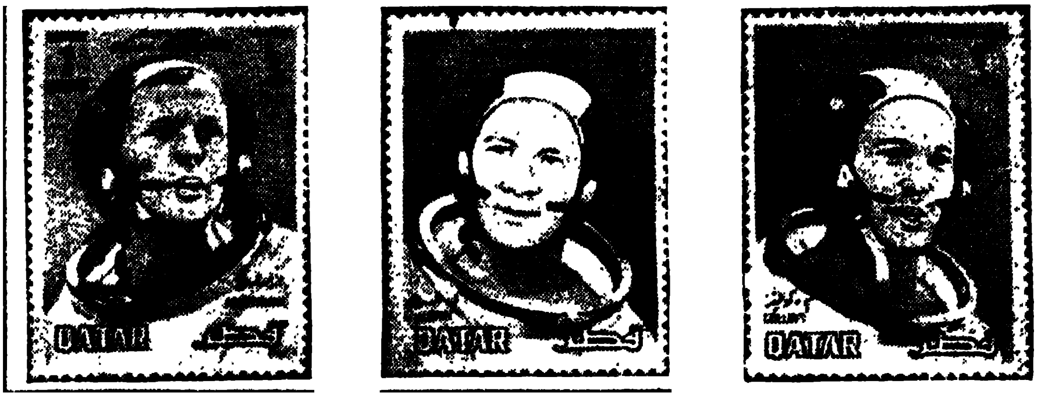
Rupin Patel



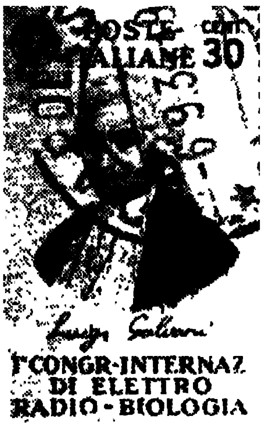
JOURNEY TO THE MOON—III

RAS-AL-KHAIMA: A set of stamps (above) depicting Apollo 11.

QATAR: Multicoloured stamps (below) issued in December 1969 to commemorate the Moon landing. Set of 6 stamps depicting the Apollo 11 astronauts.



LUIGI GALVANI: Italian physiologist renowned for his discovery of animal electricity (galvanism). By touching the nerve leading to a muscle in a frog's leg, he showed that the muscle contracts. Born on 9 September 1737, he studied theology and medicine. In 1762 he became lecturer in anatomy at the University of Bologna. He was appointed Professor in 1778. In the same year, upon the accidental discovery of twitching in the muscles of a frog's legs, he commenced researches in dynamical electricity. This led to the invention of the metallic arc — an instrument of two different metals which caused contractions in the frog's muscle when placed in respective contact with a nerve and a muscle. He attributed it to 'animal electricity'. This quickly became known as 'galvanism'.



He also did research on the hearing organs, the genito-urinary tract of birds and the irritability of tissue. He wrote a commentary on the force of electricity in muscular motion. By 1791 he formed a theory of production of electricity by animals.

His conclusions, though erroneous (Volta gave more accurate explanations), led to Volta's discovery of the voltaic cell and focused attention on the role of electricity in physiology.

Unfortunately, he could not continue his work at the university. He was relieved of his post when he refused to swear allegiance to the new regime.

On the occasion of the 1st International Congress of Electroradio Biology, Italy issued two stamps in 1934 to commemorate the Congress, depicting Luigi Galvani by photo printing.

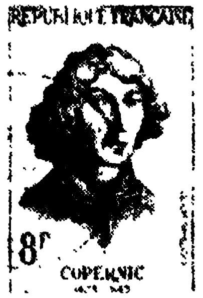
30 c in brown/buff colour; 75 c in carmine/pink colour.

NICOLAUS COPERNICUS: Polish astronomer and mathematician, considered one of the greatest figures of the Renaissance in Europe. He studied at the University of Cracow in 1491. In 1500, he began to study Greek and read the theories of Aristarchus (3rd Century BC), who had suggested the blasphemous theory that the Sun and not the Earth was the centre of the universe. In 1503, he began serious studies in astronomy.

The prevailing ideas in astronomy, religion and even politics were till then based on the theories of Ptolemy, a 2nd century Greek astronomer — that the Sun and Moon moved around the Earth in circular orbits. Copernicus challenged this by propounding the heliocentric theory of the universe, which stated that the Sun is the centre of the solar system.

He is best known for his three treatises on astronomy. In 1512, he brought out his *Commentariolus* which was a summary of his theories which were expanded later on. In 1524, *Letter against Werner* refuted Johannes Werner's collection of mathematical and astronomical papers. In 1543, the most famous of his works, *De revolutionibus orbium coelestium*, consisting of 6 books, brought out his theories in full. With the heliocentric theory, he also proposed that the stars were a vast distance away from the Earth, but thought that they were fixed to a sphere.

40 gr Polish stamp. Violet/pale violet colour. Issued on 31 March 1955 as one in a set of 8 on Warsaw monuments.



8 f French stamp. Blackish brown colour. Issued on 9 November 1957 as one from a set of 7 on famous men.

YOU TOO CAN DO IT

Auto racer

THESE little toys are very popular in many countries in the West. And they are not just toys, they require a measure of skill in operation. Why not make one at home — it will cost you only about Rs. 35.

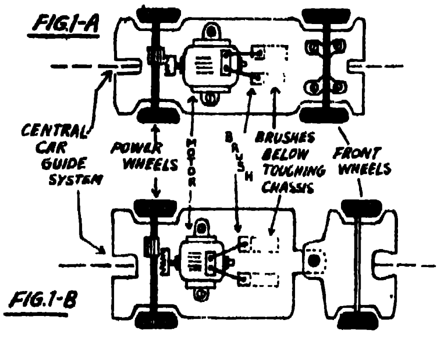
The track can be either a straight one or a curved one. The latter is more difficult to build and provides little opportunity to exhibit your driving skill. The chassis of the car is shown in Fig. 1—Fig. 1-A being the straight-track chassis and Fig. 1-B the curved-track chassis. The latter chassis has a loosely pivoted front wheel to enable the car to turn. The wheels can either be externally added or built internally, depending on the body shape. The shaft of the rear wheels is passed through an ordinary cylindrical gear and is turned by a perpendicular gear that is attached to the motor (Fig. 2). The two terminals of the motor are connected to the brushes on the chassis.

The guidance system can be of two types. In the first type, the front and rear of the chassis are slit and folded below (see Fig. 3) to give an L-shaped cut with a parallel gap. The track guide plate can run through this gap. In the second type, two stiff L-shaped wires can be attached to the centre of the front or rear end. These wires can have thin tubing at their ends to reduce friction when they touch the guide strips (Fig. 3).

The track is made of a thin, but hard, metal strip, standing vertically to a height of about 1 cm. The current-carrying strips will run beside the guide track. These strips run parallel to the ground and perpendicular to the guide track. The guide track and the current strips should not touch at any point (Fig. 4). If you wish to economise, you could use the vertical guide track itself as one of the current-carriers. Suitable adjustments can be made for the electrical connections. The track is laid on smooth wood or any other insulator.

To test your driving skill, another addition, a signal light, can be made. This consists of a buffer that can move forward and backward by means of a spring in a cylinder. A sliding contact on the buffer can pass over three open contacts on the cylinder (see Fig. 5). If you reach the end of the track with

CHASSIS



POWER TRANSMISSION

FIG. 2

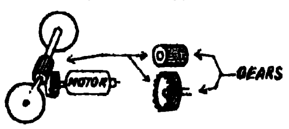


FIG.3 TRACK GUIDE SYSTEM

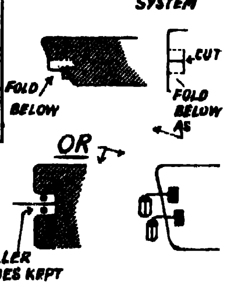


FIG. 4 POWER & TRACK

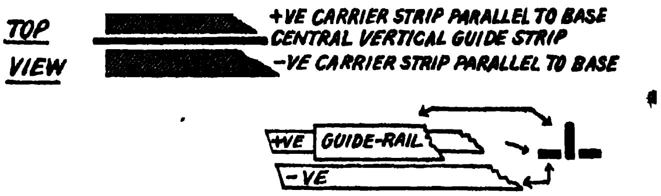

TOP VIEW
+VE CARRIER STRIP PARALLEL TO BASE
CENTRAL VERTICAL GUIDE STRIP
-VE CARRIER STRIP PARALLEL TO BASE
+VE
GUIDE-RAIL
-VE

FIG. 5 SKILL DESERVING DASH SWITCH

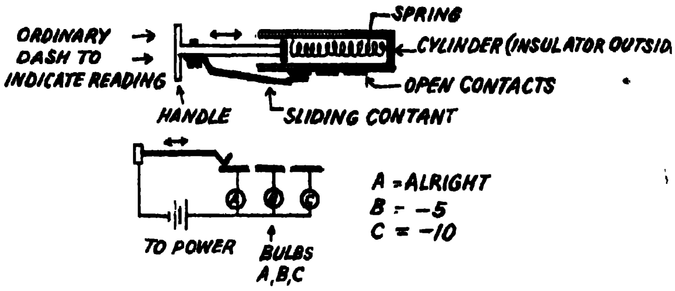
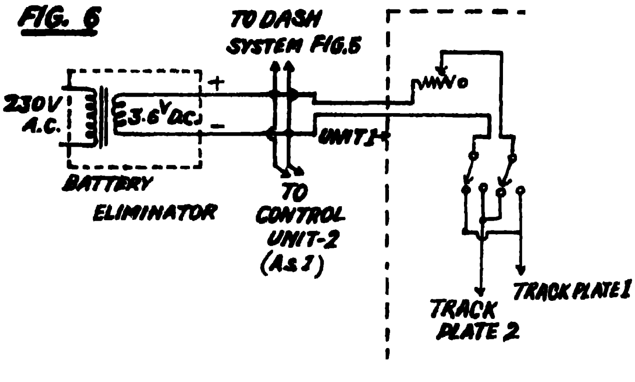


FIG. 6



HAND CONTROL UNIT 1

a big bump, the sliding contact would touch the last open contact and switch on the last signal bulb. A medium bump lights the second bulb. A perfect, gentle end switches on the first lamp. Points can be given for each bump, say —5 for a medium bump, —10 for a big bump and + 25 for a perfect drive without bumps.

The entire wiring of the circuit is shown in Fig. 6. Power can be taken either from a battery eliminator or a battery power pack. To enable the cars to accelerate or decelerate, a wire-wound variable resistor with a switch can be made on a glass tube with any resistance wire. The backwards and forwards movement can be controlled by a two-pole two-way switch in each control unit.

Y. D. Pitkar

Automatic car headlight switch

SOMETIMES you forget to switch off your car headlights. The battery keeps discharging till it runs dead. To avoid this, you can install a unit that switches off your car headlights automatically after a set time.

In electronic timers, measurements of time are made in terms of the time constant of a condensor-resistance circuit. A condensor is made to charge or discharge through a resistance in such a manner that the voltage variation across the condensor controls the input current, i.e. the base current through the transistor, thus making the transistor conductive or non-conductive at some pre-determined voltage levels. The transistor, in turn, operates the electromagnetic relay.

An extremely interesting circuit is the common emitter compound connection of transistors. This circuit is also referred to as the Darlington pair. The emitter terminal of Trl is directly connected to the base of Tr2. The collectors of both the transistors share a common relay load. These two transistors present only three terminals to the external circuit. The current gain of such a circuit is the product of the individual gains. Since Tr2 is in a common leg of Trl, it will provide negative feedback that will stabilise the gain and the resulting input resistance will be much greater than the single common emitter stage. Hence, the discharging path of the condensor will also include, in series with 100 k, the equivalent input resistance of the Darlington pair.

The time delay of the unit can be set by trial. You can increase or decrease the interval by simply increasing or decreasing the value of the condensor C. When the ignition is switched off, the relay stays on for the time determined by the discharging rate of the condensor. When the voltage across the condensor falls below a certain value, the relay automatically switches off.

This unit will work satisfactorily on all cars having a 12 volt battery and a negative earth. Apart from switching off the headlights, the unit can also give delayed switching off action to any other light or electrical accessory, provided it has got a sufficient number of contacts.

The negative side of the unit is connected to a suitable point on the chassis of the car. The positive connection is connected directly to the 12 volts positive terminal of the car battery. The normally open relay contacts are to be inserted between the cable running from the headlights to the headlight switch.

You will need:

Transistors: BC 107 or BC 108 or BC 109 (two pieces). Diodes: BY 126 or BY 127 or any silicon diode (one piece); OA 85 or OA 81 (one piece.) Condensors: 125 Mfd — 16 volts (one piece); 250 Mfd — 12 volts (one piece). Resistance: 100 K ohms

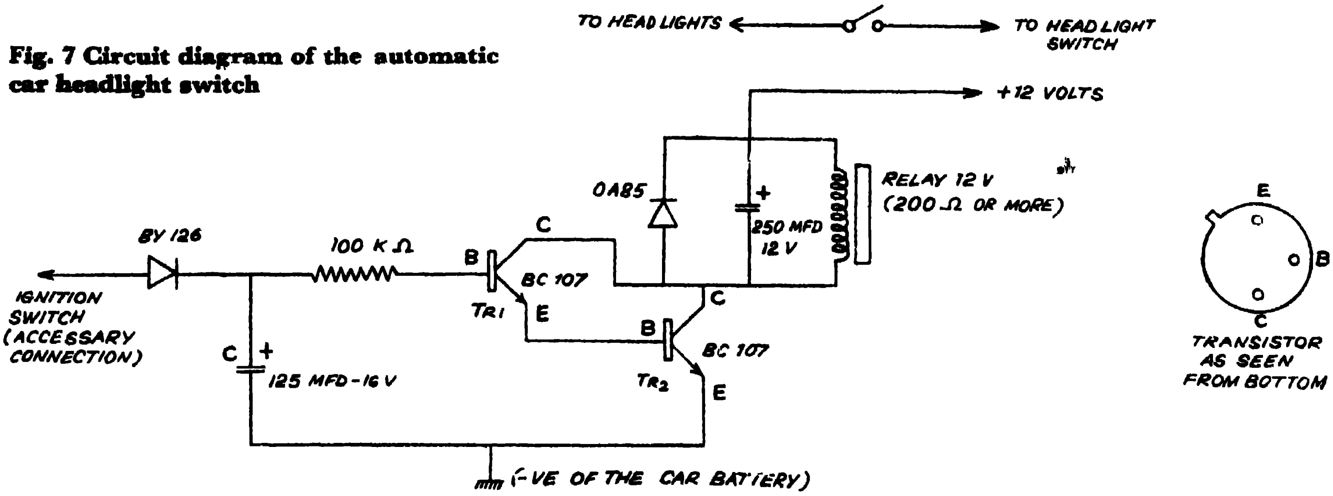


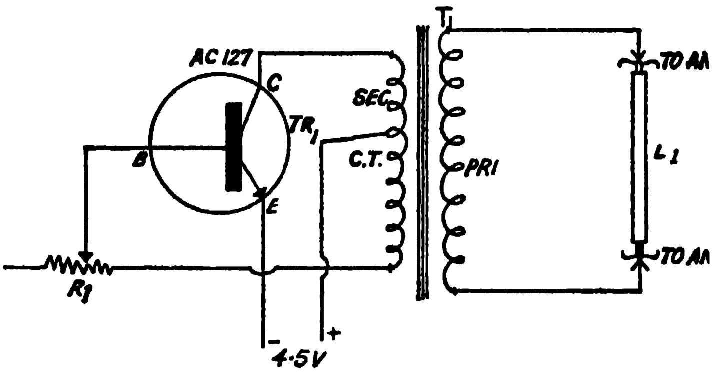
Fig. 7 Circuit diagram of the automatic car headlight switch

— ½ watt (one piece). Relay: Electromagnetic—12 volts DC (one piece); (200 ohms or more), with at least 2 changeover contacts.

Anil V. Borkar

Battery-operated tubelight

WHAT do you do when the lights go off? Grope around in the dark for a torch or a candle, praying for the power failure to be short-lived? This situation could be avoided if you keep a battery-operated tubelight handy. Of course, nowadays they sell many 'mains failure lamps' but these are expensive items. A home-made tubelight, which incidentally is more powerful than a torch, would cost only about Rs. 20 to make.



The figure illustrates the circuit for this battery-operated tubelight. It is a simple oscillator circuit with an AC127 transistor as its heart. In fact, any transistor can be used. If you use a PNP transistor, however, be sure to change the battery leads, i.e. the emitter to the positive (+) and the centre tap of the negative (—). The 5K potentiometer varies the base current thereby increasing or decreasing the brightness of the light. But remember — don't touch the ends of the primary section of the transformer when 'on', for if you do, you get a big, though not dangerous, jolt.

Your will need:

R_1 — Potentiometer, 5K ohms. Trl — Transistor AC127 (NPN) BEL. T_1 — Step-down transformer; pri: 230–250 volts, sec: 6–0–6 volts. L_1 — 10·6m tubelight. Battery, 4·5 volts. Solder, lug-strips, etc. Power transistors OC26, OC27, AD139, AD149 can be used instead of the usual transistors for a more powerful light.

Jaishanker S. Nirodhy

My cup of tea

Richbru is tea that
tastes just right.
Good and rich and strong.
Cup after cup after cup
you get so many more from
every pack of Richbru

Lipton's Richbru

LIPTON'S MEANS
GOOD TEA.

A TIMES OF INDIA PUBLICATION

FEBRUARY 19

SCIENCE TODAY

FOR EVERYMA

It's the 'made for each other' blend that set the filter trend!
WILLS
NAVY CUT
FILTER TIPPED
MADE IN INDIA
THE WILLS HOUSEMARK OF QUALITY

The smoking satisfaction comes from hand-picked tobaccos and a highly efficient filter perfectly matched to make

WILLS FILTER
the largest-selling
filter cigarette in all South Asia.

Maximum Price
Re 1 for 10 Rs 2 for 20
subject to local taxes

At the Victoria Memorial, Calcutta

WF 5898-2

Vol. 5 No. 8 February 1971

SCIENCE TODAY

ARTICLES

THE SOCIAL CONSCIENCE OF SCIENCE by M. G. K. Menon 13

Individual scientists, well-known and otherwise, have in response to their conscience tried to take a stand on questions relating to science and society. It started with Alamogorado; today the issues are wider

THREE-AND-A-HALF MINUTE MILE ? by Roger Bannister 22

Record-breaking does not depend on sheer strength and stamina. It needs the application of fresh knowledge on how to use muscles and the circulatory system more effectively

THE KILLER WAVES 30

The name ' tidal waves ' as commonly used is a misnomer. The giant killer waves are usually the tsunamis and the storm surges of cyclones. Also a pictorial feature on the recent cyclone in Pakistan

THEY THROW MONEY AWAY ON PURPOSE by Steve Bacon 42

They drop purses on purpose. And anyone who picks one up may be an unwitting model in a study of pro-social human behaviour

FEATURES

About the Authors 5
Awards & Appointments 6
Letters 7
Science Shapes Life 8
Round-up of Research 28
Blurs & Bright Spots 41
Brain Teasers 47
Desert Farming 48
Test Your Knowledge of Spiders (Quiz) 50
The Animal World 52
Books 55
Question & Answer 56
How Does It Work? 57
For Young Readers 59
Science on Stamps 64

COVER Storms sweep giant waves on to the land and wreak havoc on life and property (*Painting by M. S. Talwalkar*)

Annual Subscription Rs. 12·50

Single copy: Rs. 1·25; 2s

Editor
Surendr Jha

Printed and published for the proprietors Bennett, Coleman & Co., Ltd., by Pyarelal Sah at Times of India Press, Bombay, India. Delhi Office: 7, Bahadur Shah Zaffar Marg, New Delh
Calcutta Office: 13-1 and 13-2, Government Place East; London Office: 3, Albemarle Street, W

for better welding, use

ADVANI-OERLIKON

job-rated electrodes, fluxes and performance-proved welding equipment—

We are India's leading makers of welding consumables and equipment. There is hardly any welding job for which we do not make the right electrodes, fuxes and welding equipment. Because we make the largest range, too.

Continuous research in welding technology makes our products measure up to world standards in quality and performance. That's why they are now used with confidence the world-over. Besides, we back our products with expert technical advice on individual welding problems.

So for better welding, job after job, why not use ADVANI-OERLIKON electrodes and welding equipment?

ADVANI-OERLIKON

Welders to the nation

ADVANI-OERLIKON PRIVATE LTD.

Regd. Office: RADIA HOUSE,
6 RAMPART ROW, BOMBAY-1

Area Offices: Bombay, Calcutta,
New Delhi, Raipur, Madras

Plants: Bombay, Poona, Raipur,
Madras, Visakhapatnam

About the Authors

M. G. K. Menon (*The Social Conscience of Science*) is Director of the Tata Institute of Fundamental Research, Bombay, and a Fellow of the Royal Society of London. He is also Member-Secretary of the International Union of Pure and Applied Physics.

Prof. Menon's field of research is cosmic rays, which he studied under Nobel laureate Cecil Powell at Bristol. Prof. Menon was responsible for the first clear observations of cosmic ray high energy neutrino reactions. He also demonstrated the existence of muons of varying energies, mono-energetic high energy pions and electrons amongst the decay products of heavy mesons.

This article is abstracted from the Fifth J. N. Tata Lecture he delivered recently at the Indian Institute of Science, Bangalore.

ROGER BANNISTER (*Three-and-a-half Minute Mile?*), the first man to run the mile in under four minutes in 1954, is Chairman of the Research Committee of the British Sports Council. He is consultant neurologist to three London hospitals. Before qualifying as a doctor he worked as a research physiologist.

This article is reproduced from *Science Journal*, November 1970.

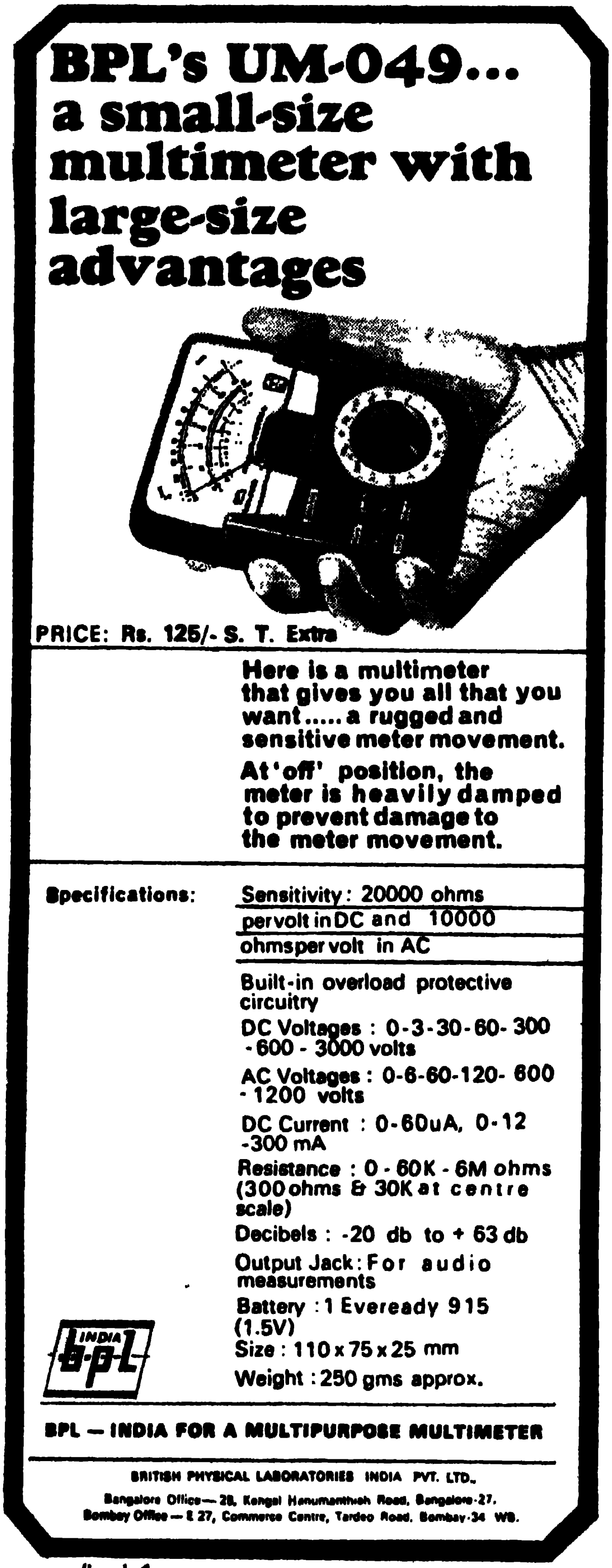
● ●

STEVE BACON (*They Throw Money Away on Purpose*) is a science writer from the United States.

IN THE FORTHCOMING ISSUES . . .

INTERPLANETARY PARTICLES
BLOOD GROUPS
PLANNING FOR WATER RESERVOIRS
SEX, DRUGS AND ETHICS
DRUG ADDICTION AND ITS EFFECTS
HOW TO SUCCEED IN A NEW TECHNOLOGY ENTERPRISE
THE WORKING OF THE BRAIN

"D-SIL"
BRAND
THERMOMETERS
AND
SCIENTIFIC
GLASS
APPARATUS
Manufactured & Sold by
DUTTA
SCIENTIFIC
WORKS
51, OKHLA INDUSTRIAL ESTATE,
NEW DELHI-20
PHONE: 220383
Head Office: MADRAS
Branches:
DELHI — SOLAN — BANGALORE



BPL's UM-049... a small-size multimeter with large-size advantages

PRICE: Rs. 125/- S. T. Extra

Here is a multimeter that gives you all that you want..... a rugged and sensitive meter movement.

At 'off' position, the meter is heavily damped to prevent damage to the meter movement.

Specifications:

Sensitivity: 20000 ohms pervolt in DC and 10000 ohmspervolt in AC

Built-in overload protective circuitry

DC Voltages : 0-3-30-60-300 -600 - 3000 volts

AC Voltages : 0-6-60-120-600 -1200 volts

DC Current : 0-60uA, 0-12 -300 mA

Resistance : 0 - 60K - 6M ohms (300ohms & 30K at centre scale)

Decibels : -20 db to + 63 db

Output Jack: For audio measurements

Battery : 1 Eveready 915 (1.5V)

Size : 110 x 75 x 25 mm

Weight : 250 gms approx.

INDIA bpl

BPL — INDIA FOR A MULTIPURPOSE MULTIMETER

BRITISH PHYSICAL LABORATORIES INDIA PVT. LTD.
Bangalore Office — 28, Kengal Hanumanthiah Road, Bangalore-27.
Bombay Office — E 27, Commerce Centre, Tardeo Road, Bombay-34 WB.

mcm/bpl,1

AWARDS & APPOINTMENTS

Prof. B. R. Seshachar of the Department of Zoology, Delhi University, has taken over as President of the Indian National Science Academy from 2 January 1971. He succeeds Dr. Atma Ram.

Apart from being Director of the Centre for Advanced Research in Cell Biology and Endocrinology, University of Delhi, and Chairman of the National Committee for the International Biological Programme, Dr. Seshachar is also on several committees on education and science in India. But it is as President of the Academy that his leadership is likely to be put to a most difficult test.

The Indian National Science Academy was established in 1935 as National Institute of Sciences of India on the lines of the Royal Society of London and the distinguished science academies of the USA, USSR and France. But the Institute never seems to have attained the expected academic status and even came to be looked upon as a "conceptual failure". Scientists like Birbal Sahni, K. S. Krishnan and Homi Bhabha had earlier asserted that neither the Institute's standard nor its performance merited its recognition as the "premier society representing all branches of science in India". Bhabha was even more cruelly candid. In his presidential address to the Institute in 1963 (see SCIENCE TODAY, October 1968), he said: "It is with great regret, that I have to say, 20 years later, that the quality of the membership has not reached the level that it should have, and that the Institute does not, therefore, have that academic standing in the world of science which it should have achieved by now. I am convinced that 20 years is a long enough time for this change to have taken place, and if it has not, then I see little to convince me that it will take place in the next 20 years."

He also noted that "while it is said that the National Institute has in its fellowship some of the best scientists in India, the fact remains that there is a considerable number of very good young scientists who are not amongst its fellows. Moreover, I have watched the elections carefully over a period of years and find that often in the same subject it is not the best and most outstanding research worker who is elected but one who may be senior or one who may have more influence in view of the administrative position he holds. This is not the way a great academic body and a great academic tradition can be built up."

LETTERS

Clock Paradox

I refer to the article "Clock Paradox" by Kamlesh Ray in the September issue of SCIENCE TODAY. His statement that a spaceship which returns from a trip far out into space will synchronise its time and ageing as soon as it returns to the Earth is not borne out by facts.

Imagine a planet or a star 10 million light years away and stationary with respect to the Earth. Assume that a spaceship which starts from the Earth and moves with a velocity so close to that of light that it takes one year for the spaceman to reach the star. This can happen because the distance between the Earth and the star contracts to an extent given by $l = l_0\sqrt{1 - v^2/c^2}$ as far as the spaceman is concerned. At $v = c$, this becomes zero. In fact, at $v = c$ the whole universe will be seen in a single plane by the spaceman. In the case of our spaceman, l is 10 million light years and T the time taken by the spaceman to reach there.

From the equation, $L\frac{\sqrt{1 - v^2/c^2}}{v} = T$ we get v/c very close to 1. (The calculations have been omitted.) As soon as he reaches the star he moves with the same speed as the Earth system. The spaceman now returns to the Earth in 1 year, thus taking in all 2 years for the to and fro journey according to his watch whereas the Earth would have passed 20 million years when he returned.

The paradox can be resolved only if we consider distances in the spaceman's system. In other words, we shall have two spaceships, A and B, separated by a long distance and moving at very high velocities with respect to the Earth though they are stationary with respect to each other. Suppose the Earth passes the two spaceships A and B one after the other in that order. An observer from the Earth measures the distance between the two spaceships, contracted by a factor of $\sqrt{1 - \frac{v^2}{c^2}}$. Hence the time taken by the Earth to move between the two spaceships will be much shorter than that observed by the spacemen. If the distance between the two spaceships were 10 million light years and if the spaceships were to move with the same velocity with respect to the Earth, as in our previous example, then the spacemen in spaceship A will observe the time taken for the Earth to cover the distance between the two spaceships as 10 million light years though for an observer on the Earth it amounts to taking only one year. Hence there is no contradiction here.

K. Thyagarajan
New Delhi

Using the term relative rather erroneously, Mr. Ray arrives at absurd conclusions in his interpretation of the clock paradox. He seems to have ignored the second fundamental postulate used in the development of the special theory of relativity. It states that the velocity of light in vacuum is absolutely constant, irrespective of the relative motion of the source and the observer. This is justified by explanations of the negative results of the Michelson-Morley experiment, the Trouton-Noble experiment and in the measurements of the velocity of light using the Michelson's rotating mirror method, Homer's astronomical observations on the satellites of Jupiter and De Sitter's work on variable stars. The relativistic law of addition of velocities also leads us to the same conclusion.

Time and space are relative quantities and are functions of velocity. Since 'contraction' or 'expansion' are in themselves relative terms, they merely signify differences of these dimensions within the frames of reference whose motions are mutually relative.

A spaceman moving with respect to the Earth with a certain velocity can never claim that the Earth or the solar system is moving with respect to him with that velocity, for on comparing his length and time-scales with that of the Earth, he will certainly find them contracted and unrelated to the Earth scales. In fact, they will be relatively expanded! By using the term 'relative' in this erroneous sense, one can also say that the projectile is stationary and it is the Earth and its solar system which is projected. This is impossible for reasons of gravitation and dynamics.

Ashok Kumar Singh
Varanasi

[Mr. Ray replies: The clock paradox involves uniform relative velocity between two systems as the formula provides. The transformations (length, time and mass) are based on the constancy of the velocity of light. While in motion, the two systems show their relativistic effects to each other. When the two systems reunite, their contemporaneity is established. The paradox is thus explained with the relativistic time-change remaining valid. The case of longer life of mu-mesons is not a contradiction since the decay period is longer while moving fast.]

Tachometer

In the quiz "How Many Scientific Instruments Do You Know?" (SCIENCE TODAY, September 1970), it is stated that a tachometer is an instrument for measuring aircraft and motor boat speeds. The tachometer is merely an instrument to indicate the rpm (revolutions per minute) of a machine element. Speeds of aircraft and motor boats are generally measured by an instrument which can sense the difference between static and dynamic pressures of the fluid medium in which the vehicle operates — the pilot-manometer in the case of aircraft and the pressure-vane speedometer in the case of boats. The latter has as its sensing unit a submerged pivoted vane which is progressively deflected by water pressure as the speed of the boat increases.

Anthony Koithra
Cochin

SCIENCE SHAPES LIFE

SMALL FAMILY AND BRIGHTER CHILDREN

The family planning programme has gained momentum in India. Apart from the larger objective of limiting the population, what are the merits of a small family?

" Children from small families tend to be brighter, bigger, more vigorous and more responsive " than children from large families, reports *Science Digest* from a survey conducted by the Population Reference Bureau, Washington DC. Personal relations are also better among members of a small family, the survey says.

On the other hand, in large families, parents, particularly mothers, usually lose their health; adjustment between the parents also seems to be more difficult as the family size grows. Other general observations are that large families tend to be less planned and conformist, while small families develop " rationalism and prudence ". There, then, you have a strong motive to plan your family.

FILTER DECREASES CANCER

The use of filters decreases the risk of lung cancer in smokers. The journal of the American Medical Association reports this finding after a study of smokers who switched over to filters for 10 years or more. The study showed that lung cancer risk decreases four years after one stops smoking; in about 13 years one returns to the health level of a non-smoker. The study included 350 lung cancer patients and 700 others without diseases related to smoking or tobacco.

" TEST-TUBE " PIGS ?

The genetic material transfer technique went a step ahead recently when a sow gave birth to three piglets in England. The sow had been earlier implanted with fertilised eggs taken from four donor pigs in Canada and flown 5,000 km across the Atlantic. The idea is to cut the cost of importing pigs which costs ten times more.

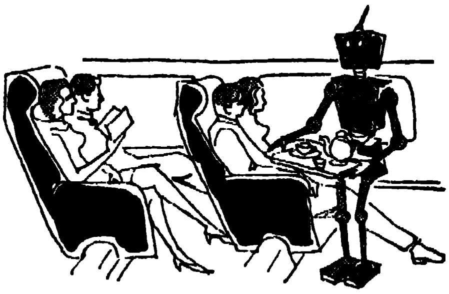
The success of this experiment has been attributed to new techniques such as pre-natal testing which avoid the danger of the off-spring inheriting a disease and the use of drugs which synchronise the sexual cycles of the donor and the recipient pigs. Canadian scientists are trying to extend the experiments to other animals whose eggs have different survival periods; pigs' eggs survive for up to 48 hours in normal conditions.

TWO NEW GALAXIES SPOTTED

Astronomers have been scanning space in search of new galaxies after an Italian astronomer, Paolo Maffaei, reported in 1968 that he found two strange objects in infrared photographs. The strange objects have now been identified as two new galaxies, 3 million light years from the Earth (a light year is about 9·5 trillion km). The tracking was done at four different observatories.

WATCH OUT FOR LOW VOCABULARY

Action and magniloquence usually do not go together. Or, perhaps, criminals do not believe in mincing words. A report by the US National Advisory Commission on Civil Disorders concludes that crime is linked with weak vocabulary. The observation has been verified against statistical data on human aptitude measurements and correlations for over 50 years. Criminals are usually weak in recognition vocabulary such as the use of right handles, the report states. Abstract ideas such as justice, honesty, the basis of law, courtesy and concern for others are a little far from their minds.



SPEEDING TO 2000 AD

The Russians are planning to fly a completely automated superfast plane in the year 2000. The plane, according to a leading Soviet aircraft designer, will not take more than two hours to reach any place in the world. Passenger services aboard will be handled by robots. However, there will be a pilot in the cabin to give assurance to passengers.

The plane, it is said, will fly at a speed of up to 10,000 km an hour at altitudes of up to 30,000 metres. At this speed and altitude, the outer cover of the plane is expected to be subjected to a temperature of about 550°C.

ULTRASONIC STITCHING

Ultrasonics have been now brought to the aid of dress-makers. Ultrasonic vibrations produced by an electronic device can " sew " two pieces of clothing by making one piece vibrate against the other. This causes a molecular change in the fabric and welds them together. The technique, it is claimed, can also be used to make films, blankets, bandages, filters, oilcloth and other synthetic materials.

BRAIN-COMPUTER TALK

Direct brain-computer communication, achieved recently for the first time, may help in treating mental and physical disorders. Dr. Jose M. R. Delgado of the Yale School of Medicine, USA, stuck electrodes in the brain of a chimpanzee to establish a feedback link with a computer for his experiments. The wave patterns produced by the electrical impulses in the brain were recognised by the computer. A signal from the computer stopped the wave activity.

HEART CURE WITHOUT TRANSPLANT

While rejection and post-operative complications in heart transplant cases still remain a problem, research has now turned to a cure without transplant — using a vein from the patient's leg. The saphenous vein from the leg is removed and grafted to the heart to bypass a blocked artery. The technique is helpful only in cases where the heart trouble is due to the constriction of coronary arteries. And most of the heart damages are caused by blood clotting in the coronary arteries — arteries from the aorta which supplies blood to the heart.

The operation was pioneered in the Cleveland Clinic, Ohio, USA, where 1,400 patients have been treated successfully. In Britain, more than two dozen operations have been carried out with good results, but the British Heart Foundation wants more research before accepting the method. For this, it has now given a number of research grants to surgeons.

The operation takes only about 3 hours against 9 hours for a transplant. According to a British heart surgeon, the method could be successful " in nine out of 10 cases where a transplant would have been the last hope".

THOSE CLEVER DOGS !

When dogs pant, there is an efficient mechanism at work to keep them cool, reports *Science*, a US journal. For though, when they breathe open-mouthed, dogs appear to inhale and exhale air through the mouth, actually it is not so; they breathe in through the nose and breathe out through the mouth. Tests have established that this is an efficient way of keeping cool.

The moist ' turbinate ' surfaces in the dog's nose absorb the excess temperature and moisture content of the air and brings it to the required level. If air is exhaled through the nose, the same process is repeated and the temperature and the moisture content in the exhaled air is retained in the body. It has been shown by experiments that exhaling through the mouth carries away twice the amount of heat.

SEMICONDUCTOR LASER

Bell Laboratories, USA, have developed the first semiconductor laser which will operate at room temperature. As lasers found varied uses, semiconductor lasers had been built even earlier, but the snag was that the excessive heat they generate does not permit them to function at room temperature for more than a fraction of a second. They can be improved using heat sinks and refrigeration, but that is very costly. The new laser operates on dry cells and is smaller than a grain in size. It requires a low current density (2,700 amperes/cm^2 against 100,000 amperes/cm^2 for earlier ones) which is why it does not generate much heat. The laser may be used in data and voice transmission on optical telecommunication channels and in optical electronics.

The laser has " four layers of gallium aluminium arsenide alternating with gallium arsenide ". The layers are smeared with tin, silicon, zinc and germanium atoms. The light is limited to a narrow active region which results in a low threshold current requirement.

FILL A LAKE AND START A QUAKE

That is not just an attractive slogan. In certain circumstances, by filling a large lake, you may be actually triggering an earthquake. This was the conclusion of a group of geophysicists who discussed the " seismic phenomena associated with large reservoirs " at the UNESCO headquarters in Paris recently.

What is of interest to India here is that one of the scientists, Prof. Jean-Pierra Rothe of the University of Strasbourg, said that the Koyna earthquake in 1967, which killed 177 and injured 2,300 persons, was because of the filling of the reservoir behind the Koyna Dam. Earlier, a committee of experts appointed by the Indian Government had reported that the earthquake was due to geological faults in the area.

Other examples of water impounded in large reservoirs setting off earthquakes include Lake Mead, behind the Hoover Dam on the Colorado River in the US, where 6,000 shocks occurred in ten years after the lake was filled in 1935 and the Kariba Dam on the Zambesi River.

However, in most cases, filling of lakes has no significant effect on the seismicity of an area. Special geo-tectonic conditions should exist to create earthquakes.

There are at present several explanations of how reservoirs can start earthquakes. One is the actual weight of the water itself. A hundred billion tons or so of water deform rock layers but natural stresses are of far greater importance. The rocks might have been subjected to such stresses before the reservoir was filled, perhaps " adding the last straw to break the Earth's back underneath it ".

The pressure of water along joints and faults in the Earth's crust, called the pore fluid pressure, may be increased when the water level is raised in a reservoir. Then the water does not " lubricate " the rocks as much as it separates them by flotation. The result is slippage and an earthquake.

The UNESCO group recommended, among other things, the study of strong ground movements associated with these earthquakes, the effect of pore fluid pressure on failure of rock masses and the establishment of a central bank of world data on the seismicity of large dams.

SPREADING FEAR THROUGH TV ?

How far do political propaganda and mass communication influence a child's thinking? A US study has shown that they can change a child's attitude to various external phenomena and his mental preoccupation.

Children usually fear noise and animals, darkness and supernatural events. These fears shift to bodily injury and punishment for bad behaviour during the age 8 to adolescence. These were the findings of a survey conducted about 40 years ago. But, in a recent study by Dr. James W. Croake of Florida State University, almost constant worry about politics, communists taking over the country, war, etc topped the list of fears among children. This, Dr. Croake says, is something new, and may be attributed to the Viet Nam war, the TV and improved mass communication.

The survey, which covered third and sixth-grade students from 12 schools in 2 States, also revealed other fears which include bugs, wild animals, ghosts, darkness, tornadoes, thunder and lightning, personal relations, school tests, punishment, anxiety about the safety of parents, injury and body weight.

PLASTIC BAGS SPEED UP RELIEF

During times of disasters like cyclones and floods, relief, in the form of food or clothing, should reach the victims fast. Usually, these are airdropped using parachutes. A German firm has now made a plastic container which can be airdropped without parachutes and yet remain intact on hitting the ground. The container has a rubber bag, with a stoppered spout, welded to an outer casing made of a special fabric coated on both sides with PVC. The outer casing has a small opening for the spout through which the bag is filled. The bag is not filled completely to distribute the impact pressure uniformly on hitting the ground.

GLASS FIBRE TO REINFORCE CEMENT

Like steel and plastics, glass fibre can be used to reinforce cement. But efforts so far in doing so had been thwarted by the alkali action of cement. Alkali-resistant glass fibre has now been developed by Fibreglass Ltd., England, in collaboration with the British National Research Development Corporation. The material, it is claimed, has been found to enhance the impact and tensile strength of cement and also give it greater fire resistance.

Glass fibre reinforcement is expected to give a greater flexibility in designs for buildings and a wider range of shapes. The NRDC predicts advances in shell structures for buildings using fibre glass reinforcement. The material will be marketed under the trade name Cem-Fil.

CONTINENTAL PIECES PUT TOGETHER

As seismic and geomagnetic observations bring forth new evidence to support the theory of continental drift (see Science Today, January 71, p. 22), two American geophysicists have been able to reconstruct the shape of the giant land mass that the Earth is supposed to have been in the beginning and also the phases of its fragmentation into the present continents. Using continental margins, oceanic ridges and ancient geomagnetic pole positions as reference points to place continents and sea-floor features, Drs. Robert S. Dietz and John C. Holden of the Environmental Science Services Administration, US, have prepared five maps which show the course of the break-up of the giant continents and the formation of new land masses.

According to the two scientists, Pangaea, the original super-continent which included the entire land mass, first split into two in the middle of the Triassic period. The continents were Gondwanaland, which included South America, Africa, India, Australia and Antarctica, and Laurasia which drifted northwards and split into two, North America and Eurasia. Gondwanaland eventually broke up into 5 continents, the separation, about 40 million years ago, of Australia and Antarctica being the last in the process. Of these, India, it is said, drifted northwards rather rapidly and collided with southern Asia; the result was the Himalayas, a range of fold mountains. Meanwhile, Africa brushed against the southern edge of Eurasia to create the Arabian Peninsula and the Red Sea.

PLUGGING IN FOR DEEP SEA OIL

Many countries, including India, have gone to the seas in search of oil. And there is plenty of it under the sea-bed, but the problem is to get it home economically. The usual method is to drill from a platform erected in the sea and connect the pipelines mechanically.

Lockheed is reported to have designed a sea-bed cellar which allows men to work normally as on land. The cellar is placed on the wellhead in the bottom of the sea and draws its supply of air and other materials from a cable connected to a ship on the surface. Oil pipelines can be manually drawn into the cellar through a water-tight hole on its side; this method is more efficient than others.

Trials have been carried out successfully at depths between 45 and 275 metres. The device, however, is designed to operate at a depth of 365 metres.

VACUUM TUBES

Vacuum tubes or thermoinic valves may be back in use if an US Navy experiment succeeds. Transistors have replaced vacuum tubes almost everywhere; they are smaller in size than conventional vacuum tubes. But transistors have certain disadvantages at high temperatures and high radiation levels. High temperatures change transistor characteristics and high radiations punch holes in the transistors because of the excess electrons. Airborne equipment are subjected to conditions of both high temperatures and high radiation.

CUTTING DOWN ON AUTO EXHAUSTS

Exhaust gases from automobiles are one of main sources of atmospheric pollution in cities; autos release carbon monoxide and other toxic hydrocarbons, particularly during braking and acceleration, as a result of incomplete combustion of the fuel-air mixture. The Russians have now come up with a pneumatic device which limits such emissions. The device, cheap, simple and weighing about half a kg, has been successfully tried in the Zil-130 and Volga cars over a long route under varying conditions.

The device includes a pressure controller and an automatic fuel switch. The controller is connected at one end to the carburettor; at the other end is a spring valve. When the pressure in the inlet manifold raises to a particular level, the valve opens to fill the intake pipe and the cylinder only with air and stop combustion completely. Besides, the device, it is claimed, also cuts down on oil seepage and minimises scale formation in the combustion chamber. A modified version of the device for 3-ton carrier vehicles is under development.

Another device that will bring the pollution-free car nearer is being evaluated at the Johns Hopkins University, Maryland, USA. It is a high-energy flywheel, spinning in vacuum at 30,000 rpm (revolutions per minute), which can provide the power needed to drive a car at a much less cost. The flywheel can be used alone or with the usual engines — combustion, diesel, gas or steam engines. In the latter type, the vehicle gets power from the flywheel during acceleration or a steep ascent.

To start with, an electric starter, working on domestic power connection, will turn the flywheel which in turn will drive a generator. Power from the generator will operate electric motors at the wheels. The electric motors can also be done away with and the energy from the flywheel can be transmitted mechanically to the wheels. It is estimated that a 1·5-kg flywheel will replace 100 kg weight of nickel-cadmium batteries. Power supply can be increased to about four times that of conventional lead-acid batteries.

Meanwhile, a Japanese firm, Japan Catalytic Chemical Industrial Company, has developed a metallic catalyst which will eliminate 96 per cent of the carbon monoxide, it is claimed. The catalyst is placed in the silencer. The nature of the catalyst has not been revealed by the firm pending patent rights, but in trails the catalyst cut carbon monoxide content from 4·5 per cent to 0·18 per cent. A serious rival to the firm is Mitsui Mining & Smelting Co., which has, under development, a " low-cost catalyst with a manganese base " which, the firm says, eliminates carbon monoxide completely.

To overcome these, the US Navy is now developing vacuum tubes as small as the transistor but more reliable. Since it works at a high temperature, external heat conditions do not affect the vacuum tube. And the vacuum protects it from high radiation levels.

3 MEV MICROSCOPE

Engineers at Osaka University and Hitachi Ltd, Japan, have built a 3 million volt electron microscope, the highest in the world. This will help scientists in probing thicker materials as electrons from such an instrument can pass through thicker samples. It gives magnifications of up to 1,00,000 times, and has a resolution of 0·46 manometre. A special feature of the microscope is a closed cell device, made of oxidised aluminium or special glass, in which bacteria and living cells live in a gas or liquid environment. This enables the study of the crystallisation process of molten metals, besides living cells.

UNDERWATER BRIDGE

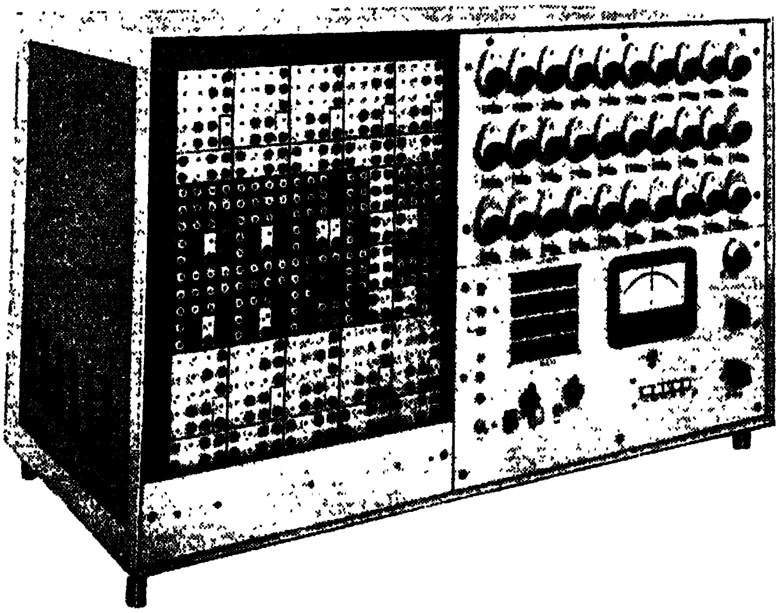
A British plan for a 3-km underwater bridge to connect Sicily to mainland Italy has won one of the six prizes awarded by the Italian Government. The plan is to have three concrete and steel tubes, held together and anchored to the seabed, floating 50 km below the water level. One of the tubes is for rail and the other two for vehicles. The tubes will emerge to land surface about a km inland to avoid steep gradients.

This type of bridge should cost less to construct than a suspension bridge, which was also proposed. Another plan was to build a sea-bed tunnel, but this means taking the tunnel deep inland to meet the land surface. Besides, the sea is 300 metres deep at places and tunnelling at such a depth may cause earthquakes. Besides avoiding these problems, the underwater bridge is not affected by high winds or heat stresses.

WELDING CABLES

Aluminium welding cables, which have replaced copper because of the high cost, have certain disadvantages; they tend to fracture under stress and it is necessary to clean them before forming connections as they oxidise rapidly. These disadvantages have now been claimed to have been overcome by coating the aluminium rod with high-conductivity copper. The copper-clad rod is then drawn into strands of required sizes. The new welding cables have been developed by an English firm, Greengate Cables.

AC-20
THE ONLY SOLID-STATE ANALOG COMPUTER WITH 0.1% PRECISION



Comes from EC

Our AC-20 Analog Computer, manufactured for the first time in India, with 20 high gain Transistorised amplifiers and matching compliments of non-linear units brings analog computation to your desk.

For performance and reliability it employs:

- Solid State Chopper stabilisation for drift correction
- Auto tracking between references to ensure precision computation
- 0.1% accuracy computing components
- 10 turn helical potentiometers.

And it also includes features like

- Over-load indicators for every amplifier
- Short circuit protection for all supplies and amplifiers
- POTSET, RESET, HOLD and COMPUTE modes of operation for precision computing
- REPETITIVE mode for fast parameter optimisation.

Extensive services available to the purchasers of AC-20 include:

Installation, Maintenance, Personnel Training, Application Advice and Documentation.

EC

ELECTRONICS CORPORATION OF INDIA LTD.,
Computer Division Cherlapalli Hyderabad-40

The people who put new ideas to work for the Nation.

the social conscience of science

M. G. K. MENON

IN the recent past there has been a profound change in the scope and sophistication of science, in its complexity and in the increase in our powers of investigation. To amplify this point let me list quickly the characteristics of science today.

The first thing one notices is that the scale of scientific advance has increased almost out of all recognition. At the turn of this century there were perhaps 50,000 people in the world who between them carried on the whole tradition of science; and of these not more than about 15,000 were concerned with new knowledge acquired by research. In contrast, over the past seven decades, the number of active research workers has grown to at least a million. The expenditure on science has been increasing at an average growth of 10 per cent per annum and more. The growth rate of science is far greater than that of any other element in society, greater than even that of military expenditure or the population explosion. There has been not just a mere change in magnitude — in the number of scientists or of funds — but a profound change in the character of science itself and in its relationship with society. There is an ever-growing dependence of industry and government on science and vice versa.

A second important characteristic of recent scientific development is the rapidity with which scientific discoveries are being applied for practical ends. While it is true that many facets of current industry, such as in power and chemical engineering, depend in their fundamental character on great scientific discoveries of the nineteenth century, one can list a whole host of new areas such as nuclear energy and the use of isotopes, electronics (including radar and television), plastics and synthetic fibres, hormones and antibiotics and many many others which are applications of fundamental scientific discoveries of the 20th century.

The third characteristic has been the application of science to armaments. This aspect has always been part of man's history, to survive in a hostile environment. And one can find examples, such as the discovery of gunpowder, in which man made use of his thinking powers in this direction. But the really significant developments occurred in World War I, with the development of bomber aircraft, of tanks and of poison gas. And it was brought out in a truly spectacular way in World War II, with the development of radar and of atomic weapons of frightening power, to name only two major entities. Over the past two decades these military applications of science have continued unabated with missiles and anti-ballistic missiles, guidance and control systems that have proved themselves capable of pinpoint accuracy in the manned Moon landings, weapons for chemical and biological warfare, the use of space vehicles for surveillance, nuclear-powered submarines and so on.

And, finally, we can trace the transition from the era of private science, at the beginning of this century, through the era of industrial science, to the present era of governmental or public science. The venture is now so large and all-embracing that support for it has essentially to be public and governmental — both national and international.

Let me give two obvious examples to illustrate the change of scale that we are concerned with today. Since ages immemorial, in the use of fire and in all biological and chemical processes, human society has been concerned with the energy characteristic of chemical reactions. These have involved atomic and molecular rearrangements; and the energies are measured in electron volts. It is only in this century, with the birth of nuclear physics, and particularly over the last quarter of a century, with the release of nuclear energy in its largescale destructive and constructive forms, that we have dealt with energy releases measured in millions of electron volts; and the factor of a million is indeed very large.

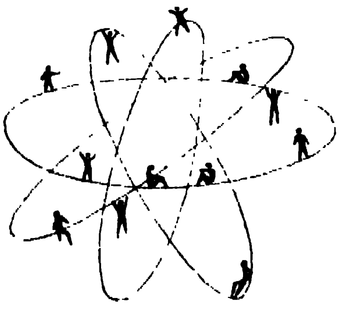
In a very different direction, let us consider the modern miracles of medicine and the population explosion. The human race has essentially developed thus far on the basis of "survival of the fittest". Man has been subject to diseases and pestilences and has gradually learnt to overcome these. In these efforts of his, there have been major successes over the past two centuries, particularly in the control of communicable diseases. And more recently, since the 1930s, the successes have been indeed spectacular with the introduction of the miracle sulpha drugs and then of antibiotics.

Through the first million or so years of man's existence, the population probably doubled every 50,000 years. Now this doubling period is only 35 years! The first flakes of snow that came down the mountain side are now an avalanche. In India, while the birth rate dropped from a figure of 51·3 in the first decade of this century to a figure of 40 during the 1960s—a decrease of 11·3 per thousand, the death rate dropped from 43·1 in the first decade of the century to 16 in the 1960s, i.e. a decrease of 27 per thousand. And the expectation of life at birth increased from 23 years at the turn of the century only by 9 years to 32, half a century later; but then it increased by 18 years from 32 to 50 years in another 15 years only. The population growth since 1800 and the likely rate of growth in the years ahead are producing changes which have no parallel in the history of the human race.

The millionfold increase in energy release arising from nuclear discoveries and the population explosion made possible through medical discoveries are truly live and explosive problems of concern to society.

Bertrand Russell once said, "equations do not explode"; and most scientists in their ivory towers have been confidently working on this assumption, that what they are involved in is purely a process of objective and logical reasoning which has very little to do with human society and its real problems. But the manner in which science has grown and is continuing to grow, the rapidity with which scientific discoveries are being applied to practical ends in the present symbiosis of science and technology, and the rapidity in the application of science to armaments, have all resulted in an explosive situation.

The American philosoper, Herbert Marcuse has written recently: "When the most abstract achievements of mathematics and physics satisfy so adequately the needs of IBM and the Atomic Energy Commission, it is time to ask whether such applicability is not inherent in the concepts of science itself." This being the case, the scientific community has to consider not only what is generated as fundamental knowledge, but the entire cycle which leads to application, its impact on society and the long range consequences for the human race. Science cannot occupy such commanding heights of power in relation to society and not concern itself with all that stems or follows from its actions.



"Equations do not explode!"
—Russell

Some other things do. The atom, for instance, or population

One cannot, of course, say that this concept is highly original. Sir Francis Bacon had written much earlier: "Human knowledge and human power are coextensive." And with the growth of science and increase in human knowledge, there has been a corresponding enormous growth of human power that we have to learn to live with. And it was always recognised, particularly by Bacon, that the advancement of knowledge could be used to support both good and evil purposes. After speaking of the benefits flowing from the advancement of science, Bacon says: "Yet out of that same fountain come instruments of lust and also instruments of death. For not to speak of the arts of procurers, the most exquisite poisons, as well as guns and such-like instruments of destruction, are also the fruits of mechanical invention; and well we know how far in cruelty they exceed the Minotaur himself."

And it was when science created the monstrosity of nuclear weapons that its social conscience was awakened in a significant collective way.

The nuclear era

The most destructive form in which science found application in the history of the human race was in the development of the atom bomb. The development was inspired by the honest conviction that this was the best, and in fact, the only possible countermeasure available to meet any possible threat of atomic warfare by Germany.

Over the 300 years, prior to the outbreak of the World War II, each new contribution to knowledge of the secrets of nature had been welcomed in the name of progress. But in January 1939, for the first time, the scientific community hesitated. In a vain attempt to prevent information that might be important for the development of nuclear weapons falling into the hands of Germany, Leo Szilard suggested to Enrico Fermi that scientists should impose a voluntary censorship on their work. Szilard's idea prevailed to some extent in the United States and was accepted by men like Wigner, Weisskopf and Teller who felt that the situation in the world was an exceptional one and demanded exceptional measures. But it did not gain acceptance amongst European scientists and ultimately had to be given up.

Szilard and his friends were then concerned with the question of how best to impress on the US Government the importance of recent work in nuclear physics and its implications for weapons development. Szilard achieved success when he convinced Einstein of the possibility of a chain reaction in uranium and its consequences; and got through to President Roosevelt a letter signed by himself and Einstein. Later history has shown that the menace of a German uranium bomb, which triggered all of this thinking and effort, was nothing more than an unsubstantial bogey. Einstein said with deep regret after the war, "If I had known that the Germans would not succeed in constructing the atom bomb, I would never have moved a finger."

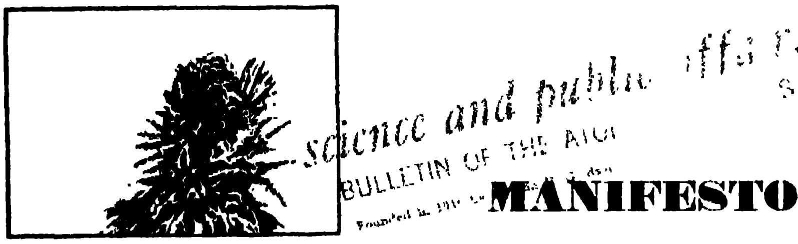
"If I had known that the Germans would not succeed in constructing the atom bomb, I would never have moved a finger."

The Manhattan Project proved eminently successful with the explosion in July 1945 of the first test device at Alamogordo. Prior to this, during the spring of 1945, a study group within the Manhattan Project that included Oppenheimer, worked on the selection of a target for the first employment of the bomb. In the months prior to the first test explosion, a high power committee had been set up to advise President Truman on all matters relating to atomic policy; the scientific panel of this committee had on it Oppenheimer, Fermi, Compton and Lawrence. The feelings of many scientists at the time just prior to Alamogordo test were put by Szilard as follows: "During 1943 and part of 1944 our greatest worry was the possibility that Germany would perfect an atomic bomb before the invasion of Europe. In 1945 we ceased worrying about what the Germans might do to us, we began to worry about what the Government of the United States might do to other countries." And once again he proceeded to obtain a warning letter signed by Einstein which got to President Roosevelt's desk but was not seen because of Roosevelt's death.

Immediately after the Alamogordo test many scientists connected with the Manhattan Project signed a petition that the atom bomb should not be used on Japan without prior demonstration and an opportunity to surrender. This petition was also drafted by Szilard. This petition was considered by the committee I have already mentioned which included Oppenheimer, Fermi, Compton and Lawrence. But they said nothing when confronted by the military and political authorities with difficulties relating to other means of ending the war quickly, and which in their view would involve even greater loss of life and property. And thus on 6 August 1945, the first atom bomb was dropped over Hiroshima, to be followed soon after by that on Nagasaki. For many scientists like Einstein, Franck, Szilard, Rabinowitch and others, who had done their best to prevent the employment of the bomb, this was a black period.

Particular mention must be made of the Franck Report of June 1945, which had amongst its signatories Franck, Szilard, Rabinowitch and Seaborg. Some sentences from this Report are well worth recalling today, for we will see how true they ring: "Scientists have often been accused of providing new weapons for the mutual destruction of nations, instead of improving their well being... In the past science has often been able to provide also new methods of protection against new weapons of aggression it made possible, but it cannot promise such efficient protection against the destructive use of nuclear power.... We cannot hope to avoid a nuclear armament race by keeping secret from the competing nations the basic scientific facts of nuclear power.... We believe that these considerations make the use of nuclear bombs for an early unannounced attack against Japan inadvisable;... quite independently of any humanitarian considerations it will mean a flying start towards an unlimited armaments race. Only lack of mutual trust, and not lack of desire for agreement, can stand in the path of an efficient agreement for the prevention of nuclear warfare."

Twenty-five years after the Franck Report we can see the wisdom of the social conscience of those who wrote it. Everything they tried to communicate has turned out to be as they feared. It is a pity that a larger and more effective backing could not be given to this Report by the scientific community acting together.



"Shall we choose death because we cannot forget our quarrels? We appeal as human beings to human beings: Remember your humanity and forget the rest."

Bertrand Russell Max Born Percy Bridgman Leopold Infeld Frederic Joliot-Curie Herman Muller Cecil Powell Linus Pauling Joseph Rotblat Hideki Yukawa Albert Einstein

After 1945, the strongest protests of American scientists were directed against the plans for carrying out atomic bomb tests in the summer of 1946, since these would be bound to prejudice negotiations relating to international control. Nevertheless, in July 1946, the Bikini tests were held. A final attempt to stop a nuclear arms race was made in a proposal submitted to Andrei Gromyko of the USSR by Harrison Brown on behalf of American scientists; but this did not succeed and an escalating nuclear arms race became a reality.

The *Bulletin of the Atomic Scientists* was founded by Goldsmith and Rabinowitch to explain the social and political consequences of the 'new power.' And thus one sees that there was, on a continuing basis, the conscience of science at work in individuals and groups of individuals.

The Pugwash Movement

With the advent of an upward spiralling nuclear armaments race, many scientists all over the world began to realise that they should concern themselves with the fate of mankind in the atomic age. As a result of this realisation, several national groups such as the Atomic Scientists Association (ASA) in Great Britain and the Federation of American Scientists (FAS) in the USA began to play an active role in trying to establish an important and effective channel of communication between scientists of different nations, particularly between scientists from the great power blocs of the East and West. Eugene Rabinowitch, Editor of *Bulletin of the Atomic Scientists*, was one of the first to call and work for the setting up of international discussions.

In a speech to the House of Lords in London, as far back as 28 November 1945—only a few months after the Hiroshima bomb, Lord Bertrand Russell had not only forecast the tremendous destructive power of the H-bomb, and the resulting threat to civilisation, but also suggested discussions between scientists of the Eastern and Western blocs to achieve cooperation and international control in the field of nuclear energy and weapons. In 1954 when the nuclear menace became as great as he had predicted, Lord Russell drafted a Manifesto which was signed by Albert Einstein (two days before his death); the other signatories of this remarkable Manifesto were Max Born, Percy Bridgman, Leopold Infeld, Frederic Joliot-Curie, Herman Muller, Cecil Powell, Linus Pauling, Joseph Rotblat and Hideki Yukawa. This was one of the most appealing documents addressed to society by scientists conscious of their work and of the perils of total destruction that had arisen through this. To put it in their own words:

"In the tragic situation which confronts humanity, we feel that scientists should assemble in conference to appraise the perils that have arisen as a result of the development of weapons of mass destruction.... We are speaking on this occasion, not as members of this or that nation, continent, or creed, but as human beings, members of the species Man, whose continued existence is in doubt.... Almost everybody who is politically conscious has strong feelings about one or more of these issues; but we want you, if you can, to set aside such feelings and consider yourselves only as members of a biological species which has had a remarkable history, and whose disappearance none of us can desire.... The general public, and even many men in positions of authority, have not realised what would be involved in a war with nuclear bombs.... Here, then, is the problem which we present to you, stark and dreadful and inescapable: Shall we put an end to the human race; or shall mankind renounce war? People will not face this alternative because it is so difficult to abolish war.... People scarcely realise in imagination that the danger is to themselves and their children and their grandchildren, and not just to a dimly apprehended humanity.... There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal, as human beings, to human beings: Remember your humanity, and forget the rest."

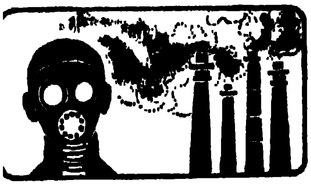
Early in 1954, the late Prime Minister Jawaharlal Nehru called for the setting up of a committee of scientists to explain to the world the effect a war would have on humanity in the context of the nuclear age. This idea was taken up and went through numerous stages of discussion and development. Finally it was planned to convene a conference of scientists in New Delhi in January 1957; this was the direct outcome of talks between Cecil Powell and Jawaharlal Nehru in 1956. This plan was abandoned, even though invitations had been sent out, because of the Suez crisis of 1956. As a result, with generous assistance from the Cleveland (USA) industrialist Mr. Cyrus Eaton, the first meeting was held at Mr. Eaton's birthplace, a small fishing village in Nova Scotia, Pugwash. And thus began these meetings of scientists called "Conferences on Science and World Affairs" (COSWA), more familiarly known as Pugwash Conferences; twenty have been held thus far, in addition to many regional symposia and special meetings. Whilst the Pugwash Movement had its origins in an attempt by scientists to remove the threat of a nuclear catastrophe, it has, over the years, developed into an international forum to discuss the problems of disarmament in general and the problems of development; for scientists see in the growing disparity between the affluent and the developing nations the future threat to world stability.

Individual scientists, well-known and otherwise, have in response to their conscience, come out and taken a stand on questions relating to science and society. But the Pugwash Movement, born out of the awareness that mankind might have to face a nuclear holocaust, was the first international group of scientists to come together, in answer to their social conscience — not just to warn society, but to strive for cooperation, for betterment of international understanding and relations, for disarmament, and to ensure that the type of understanding that led to the growth of science might be fostered for other endeavours vital for human survival, for the creation of a secure world in which the beneficial applications of science can be fully developed.

Man and environment

Another striking area where the social conscience of science has been at work is that concerned with man and his environment (See Science Today, October 1970). Man has lived on the earth for many thousands of years and has proven to be an enormously successful species. In ever expanding ways he has explored new frontiers, reached out to new environments and learnt to understand and master nature in new ways, to improve the basis of his material existence. In the beginning there was no problem for man; human society was but a small part of the environment with which he was immediately concerned, namely the crust of the earth, the oceans, the atmosphere and all else that lived in this. He could extract from the environment what he needed for his material advance, and put back waste products into it with impunity. But with the passage of time man has proliferated throughout the planet; he has subjugated other species to his own use; and released on the earth new man-made processes which match the intensity and scope of natural ones. Science and technology have been enormously successful in enabling man to extract from the environment all that man felt he needed for his material progress and which conformed to an escalating system of values that he has progressively adopted.

Saving the earth from man himself



This success of science and technology has been exponential. Society has begun to assume that science and technology can provide anything; that it is an open-ended system and the sky is the limit. But this very success, and the power that man exerts over the rest of the nature, his own proliferation in numbers as well as in what he thinks as necessary for human happiness today threaten his survival. This is a major problem to analyse and to speak about. I shall only attempt to look at some general aspects of it, particularly those in which I feel that the scientific community has a social responsibility to fulfil.

Man and the environment form an enormously complex system with many parameters that are interconnected. In such a system if the force exerted by any one component on another is relatively small, then the system as a whole can adjust itself; there are various loops available for adjustment and for feedback processes to operate. The system retains its equilibrium. However, if the force exerted is large and continuous, major changes occur in the system as a whole and these may be irreversible; and the new system that results may be one which is not conducive to life and growth that man and society have been used to and desire for the future.

Ecology—a fashionable fad?

Concern with the environment has become fashionable these days — particularly in the United States, where it is one of the dominant topics of conversation and discussion. This is not surprising considering the smog problems of their great cities; atmospheric pollution by automobiles; the growing automobile, tin-can, plastic and other indestructible graveyards; oil pollution of their beaches; blocking of the oxygen cycle in major water systems such as Lake Erie through carelessness in the use and discharge of chemicals; the increased radioactivity in the atmosphere through nuclear weapon tests and a similar unending list of man's ravages of nature.

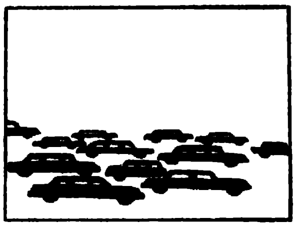
Many in this country feel that these problems of pollution are primarily ones faced by the affluent and developed nations. This is not so, and it would be a grave error on our part if we allowed ourselves to think in this way. Problems relating to the environment must be considered not only in terms of the various individual forms of pollution and specific measures to overcome these, but in the larger context of the value systems of a society; namely, what is it that society expects from life and then what the fulfilment of this demands.

Several factors have contributed to our increasing awareness of the environmental crisis. There have always been the conservationists who have been a major force in public education, on the need to preserve natural resources, wilderness areas and wild creatures. The development of nuclear weapons, as we have seen earlier, resulted in the growth of a movement among scientists to inform the public concerning grave public issues; such a movement is also now growing in respect of the environmental crisis. An additional aspect relating to the development of nuclear weapons has been the numerous bomb tests in the atmosphere and in the oceans. These have added considerable radioactivity to the environment; and it has been much easier to talk in public about the hazards, such as cancer, in the build-up of strontium 90 in the bones, than the effects of the innumerable pollutants that are discharged into the atmosphere and the oceans; about half a million man-made substances have been added to the environment already, and this number is growing by a few hundred new chemicals each year. Finally, the public is becoming increasingly aware, in a direct sense, of environmental deterioration. Even in India, oil pollution in rivers through discharge from refineries, smog over cities and similar examples of pollution are now familar.

With this experience before us, science has to move on to a new stage, of using all its powers of observation, experimentation and of logical reasoning, not to conquer nature, but to learn how to live in it, and in harmony with it. Individual scientists and individual disciplines deal with parts of the ecosystem, and may achieve success in dealing with the specific part that is their concern, but the scientific community must ensure that the different parts fall into a harmonious whole. Before the approach of systems science to ecology takes root and develops, it is the responsibility of the social conscience of science to ensure that humanity can survive the power which science has given to it.

The great advantage that the developing nations of the world have is that they do not necessarily have to follow the pathways which the developed nations have trodden, and which have led to the present problems many of these developed nations face today. There are many many examples that can be given to illustrate these possibilities.

Follow the leader.
Who is the
leader?



Let us consider the case of automobiles. In the USA, the automobile. as a personal form of transportation, has an essential place in the value system and economics of society; and today automobiles contribute in a significant way to atmospheric pollution there. Even if a clean-air automobile were to be produced, it would add to the pressure to have many more of these; the result would then be not only increasing traffic problems but also an increase in the demand for steel and power; and we must remember that the production of steel and power do contribute to environmental rundown and one should not attempt to increase the demand for these if alternate pathways exist. A possibility that should be examined is the reduction of individual transportation using automobiles and the setting up of an efficient public transportation system. Thus, before a value system and an economic pattern is built up in India following the US pattern in which ground transportation is greatly based on autômobiles for personal use, one must examine the alternative of an efficient pollution-free public transportation system; it is not that personal transportation by automobiles is to be ruled out, but that it will have limited applicability where it has particular virtue.

We can now look at a very different area, of power consumption and power production. The population of the United States is today growing at less than 1 per cent per annum. Its demands for power are, however, growing at the rate of 8 per cent or more per annum. This essentially means that, in addition to the 1 per cent rate of growth of power needed to keep pace with the growth of population, there is an additional requirement of a 7 per cent annual growth rate to cater to new needs of the same people, i.e. an upward escalating value system; even if the overall expansion of the American economy is taken into account, of the order of 4 per cent per annum in real terms, the remaining growth requirement of power is for completely new items. Where does all this power go? Some of the major uses are: production of aluminium, automobile manufacture, electric space heating, air conditioning and the paper industry. One could ask whether all these needs are truly essential, and on this scale, and thus whether so much power is really needed. Has the structuring of social needs and the attempt to satisfy these been optimised with regard to the ecological system as a whole — or has it developed, and is being allowed to develop, on classical economic considerations of profit and growth over small parts of the ecosystem?

It should be emphasised that the environmental effects of largescale power production are quite serious both in terms of waste products and of waste heat discharged into the environment.

The world is a small place today when one considers the communication of ideas. In these circumstances it would not be surprising for many in this country to aim for the same material values, the rate of economic growth as conventionally measured, and structuring of social values as seen in an affluent nation like the United States. But the population of India today is about 2½ times that of the United States, and is growing at the rate of about 2·5 to 2·8 per cent; and the area is about half that of the United States. These are important magnitudes to be taken into account.

Other pathways

Should we, and can we, in this country follow, say in power consumption, the pathways taken by the USA. We must remember that there is considerable new experience now concerning these aspects, that in our state of development we can follow other pathways, if we so decide, and this will be more difficult later, and that there are coming into existence powerful new approaches such as those of systems analysis in ecology for analysing these problems. I cannot give here an answer to the question that I have raised — but I am convinced that we should seriously give thought to it.

The question of power generation again illustrates the point I have been trying to make: namely that scientists who are aware of the various possibilities and various limitations should be intimately concerned with planning for the needs of society over the long-term future. It is not sufficient for scientists to restrict themselves to the technical aspects of an area, say power generation, and the development of these aspects over the future; and leave it to politicians, economists, administrators and the like to make the actual plans. For example, it is quite clear that for India, as well as for the world in general, fossil fuels (coal and oil) as a source of power, with the population that exists and with its rate of growth, represent only ephemeral and local solutions. Up to now, however, society has depended primarily on these sources for its power needs. For the future, and not so far ahead either, in which our children will be living, it is essential to tap a much larger source of power; and this is essentially nuclear energy.

Even nuclear energy does not have a future purely in the form of uranium burning. But it is, however, an essentially inexhaustible source of energy once the technique of the so-called breeder reactor or catalytic nuclear burners has been mastered; and even better, when the inexhaustible energy supply based on controlled fusion becomes available.

And it is towards these objectives, of perfecting breeder reactors and controlled fusion, that human society as a whole has to work for, for its own survival.

There is yet another source of abundant power in the tropics namely solar energy, on which a great deal of work needs to be done. The principal problem is that it is a very diffuse form of energy. It may be possible, however, to concentrate it locally for local needs; and to make use of it through the mechanism of chemical and biological reactions that it can generate. Its diffused character may have a built-in advantage in that its environmental side-effects will be small.

I have mentioned earlier that distortions in the ecosystem through man's intervention are not faced by the affluent nations alone. The 2 February 1970 issue of *Time* magazine had an account of problems encountered in the mighty Aswan High Dam Project on the Upper Nile in Egypt. The dam was designed around the goals of power production, irrigation, and flood control. But apparently much else has happened; the dam has greatly restricted the flow of silt down the Nile, which in the past provided an annual enrichment of the lands along its banks and offset the natural erosion of the delta. Now, downstream erosion threatens to wash away as much productive farmland as is opened up by new irrigation systems near Lake Nasser. The silt is full of nutrients which formerly found their way to the Mediterranean and made possible the growth of organisms which supported fish, including sardines. This silt no longer reaches the Mediterranean; and as a result the Egyptian sardine catch declined from 18,000 tons in 1965 to 500 in 1968.

The irrigation systems on the delta plain made possible by the dam are also having unplanned-for results: the constant supply of water encourages growth of snails which carry the virtually incurable and seriously debilitating disease, schistosomiasis. Formerly, these snails could not multiply or spread in great numbers because water filled the ditches only during the flood season. The Aswan Dam power production is threatened also; water weeds clogging the shore line of Lake Nasser behind the dam may increase water loss through transpiration to the point where the lake lacks enough water to drive the power generators. On the Indian subcontinent, we are familiar with the problems of salinity and waterlogging in the Punjab plains that have resulted from the extensive irrigation network that was developed; the Koyna dam and earthquake, the silting of the Bhakra are all facets for us to think about. Any largescale change in the ecosystem should not be looked at as an isolated measure but needs to take into account the system as a whole; otherwise there is always a price to be paid.

Scientist and society in India

There are many scientific colleagues in this country who feel that so long as they are carrying out their assigned tasks efficiently, and with dedication, and so long as they are engaged in creative research, in teaching or industrial activity for which they are paid, this is all that is required of them. I would like them to consider that they are not only scientists or paid employees, but that they are citizens of a country and of an international community; they have greater privileges and advantages compared to most of the society around them; and with these advantages go greater responsibilities. In the case of those privileged to work on pure aspects of science, I would like them to remember that society regards them highly and is therefore willing to support them to do whatever they think is exciting and interesting, in the hope that what emerges will ultimately be of benefit to society. And correspondingly they also have a responsibility towards society which has placed this trust and confidence in them.

It is not sufficient for scientists to leave it to those in authority, including government, to decide what needs to be done, and then only carry out decisions so taken. There is an enormous amount that can be achieved by individuals and by groups; and very few indeed are extended to their full intellectual, creative and physical capacity. There are many fields such as school education, adult education, smallscale industry and the like, waiting to be helped. I would like to think aloud about some general possibilities.

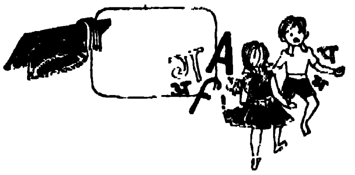
A hundred years ago eminent scientists like Huxley and Boltzmann found time to give series of lectures to large and enthusiastic audiences, sometimes made up of many thousands of working people. And they talked on aspects of science, on recent discoveries or on its bearing on familiar things. How little of this do we all do when so much more of it is needed here.

One often thinks of the wiping out of illiteracy as one of the prime objectives of an educational system. This concept goes back to the time when the sole medium for largescale communication of ideas was language in its written form — and hence the need to learn to read and write. Today the picture is not quite the same. There are new forms of mass communication — the spoken word used over the radio and the audio-visual image that can be transmitted over television or cinema screens.

Education through these does not demand a knowledge of the processes of reading and writing, which hitherto were considered essential for education. The teaching of the fundamentals of reading and writing can by itself be dry and uninteresting; and a great deal of what is learnt is lost when continuous use is not made of it. The audio-visual images on the other hand can be made attractive and exciting and have a permanent impact on the mind — in the sense of the opening up of new horizons.

It is not essential that there should be a true or total understanding of all of what has been shown; nor does education by this pattern have to follow set paths. What it has to convey is a taste for new things, a feeling for how things work, and what nature looks like. And surely this will take men from the narrow confines of their daily lives into new unexplored areas, enable them to think about these, and create in them an interest to find out more about these; and this is what education is for. Such material would have to be produced on a fairly large scale and shown to ever increasing numbers to be truly effective. The creation of material for this is not something which can be left to a defined number of paid persons or to specific agencies — though the latter can be nodal points for dealing with the many necessary detailed aspects. Scientists from different disciplines, with different backgrounds, expertise and perspectives, can contribute significantly to such a programme to convey to the much larger numbers in society, in new ways, the sense of excitement they had in acquiring new knowledge and in arriving at a new understanding of nature.

The medium is the message...



An appreciation of science or of nature by society at large, and attempts to achieve this, is fortunately not a political or commercial issue within any nation or the comity of nations. And being an area without any political and commercial overtones, there are fewer vested interests to deal with and fewer hurdles to cross. It is an area where the national and international scientific community can make a significant contribution.

There is no doubt that an individual scientist working on a problem has to be emotionally involved in it, to be constantly thinking about it and to be deeply dedicated. It would not be possible for him to make any meaningful headway if he were to be concerned with the history of the subject or its futuristic developments such as possible uses and implications for society. But the scientist is not alone; he is part of the scientific community, which has a spectrum of individuals with different interests, different capabilities and different outlooks. It is for the scientific community as a whole, to consider these problems that relate to the balanced development of science, such that in the midst of the excitement of work at the frontiers of human knowledge and providing outlets for originality and creativity, there is also consideration of the applications that will result, the impact these will make on society and the environment. In the present central position that science occupies, the scientific community has to take upon itself responsibilities for advising society and government; some of this advice may be unpalatable and may not be accepted, but nevertheless has to be given.

Most conferences, meetings and societies that scientists participate in, have as their objectives, only technical aspects relating to particular fields. There are sometimes discussions relating to social responsibilities, but these tend to be *ad hoc*, sporadic and with no follow-up. What is required is a continued involvement in these social aspects and such a role would have to be played by representative bodies of the scientific community. In the absence of these, most attempts by individual scientists or groups of these to involve themselves effectively in areas relating to the social responsibilities of science have so far been completely or mostly unsuccessful. Bodies such as national academies, that are further linked together on an international plane, could play the necessary role — but they will have to do considerable rethinking on their objectives and their manner of functioning which at present tend to be archaic, conservative and rigid before they can be effective.

In conclusion, I would like to quote the following words of Cecil Powell (see SCIENCE TODAY, January 1969): ".... Of course the solutions of many of our problems depend upon great political issues in which most scientists have no particular competence; but nevertheless, we ought to help with their resolution and never to tire in bringing before the people of the world the immense possibilities for human advancement which are now within our grasp if science is rationally employed in a peaceful world.... It may today seem like a Utopian dream, but we may remember the remark made by Pierre Curie...

" To make of life a dream, and to
turn the dream into reality...."

Oxygen supply to the muscles is vitally important in athletic performance. Modern training methods can increase this some hundred-fold from the resting level, and if athletes begin training in their teens, the mile could eventually be run in 3½ minutes. But it may take 30 or 40 years to achieve this

HUMAN interest in record breaking appears to be universal. It does not seem to matter much whether the records are made by aircraft, motor cars or men. Where machinery is involved, records are broken only with superior technology; but in the case of human achievement, the factors which limit record breaking are much more concerned with man's own mind and muscles. I am now sufficiently remote from hard exertion to have forgotten some of the discomfort of attempting to break track records, but perhaps not so remote that I cannot look back with increasing interest on its scientific aspects.

There has been a great deal of speculation on the importance of physique to athletic performance. Hippocrates was one of the first medical observers to study physique, and he classified it into *Habitus phthisicus* and *Habitus apoplecticus* — a tendency to develop tuberculosis and a tendency to vascular disease. In 1940, W. W. Sheldon in the US refined the techniques and introduced a way of measuring the extremes of physique according to three basic types. The endomorph has a physique with the maximum degree of fatness; the mesomorph the maximum degree of muscularity; and the ectomorph the maximum degree of thinness. Figure 2 on p. 24 shows a triangular representation of these variants of physique, with the endomorph — the person represented numerically by 711, with the maximum of 7 components of endomorphy and the minimum of 1 component of ectomorphy — in the bottom left hand corner. The extreme mesomorph is represented by 171 and the extreme ectomorph by 117.

Figure 2 also shows the distribution of physique within a normal population (if students can be regarded as a normal population). The central point is represented numerically by 444 and most individuals are scattered closely around this point.

The results of some work done by Dr. J. M. Tanner of the Institute of Child Health, London, on a large number of Olympic athletes are shown in Figure 1 (p. 24). The athletes' physiques lie in the upper right hand part of this triangle; in other words, they have a high component of mesomorphy and a high component of ectomorphy. In fact, the sprinters are rather more mesomorphic and the distance runners are rather thinner — they have less weight to carry for their power and are scattered more towards the ectomorphic pole. Only a swimmer can really survive with a high degree of endomorphy because the water is bearing the excess weight.

How important is physique? Of course, an athlete cannot ignore his somatotype and he has to choose the right athletic event, but there are athletic events to suit most kinds of physique. As far as the effect of physique in an individual event is concerned, it has been my experience that athletes with widely differing physiques are able to achieve a remarkable degree of success. The world record holder for the mile before the War was Sydney Wooderson. He was only 5 ft 7 in (170 cm) tall yet was able to run as fast as Arthur Wint — a runner over 6 ft 4 in (193 cm) in height. Other factors can clearly be more important than pure physique. What are they?

Other factors

The other factors are those related to physiology. The best way to start analysing these is to look statistically at how world records have changed. The world record for 100 metres, for instance, has changed relatively little. In 1921 Charlie Paddock clocked it at 10·2 seconds and it has decreased by only 0·2 second since then. Records in the distance events, however, have been tumbling with dramatic regularity, and over a comparable time, the improvement has been about 15 seconds in the mile and more than one minute in the 10,000 metres. This implies that there are different physiological factors at work in these different events.

During sprinting, there is insufficient time for oxygen to be transported from the outside air through the lungs to the muscles. It takes 15 seconds for the blood to circulate and, as a 100 metre sprint lasts only 10 seconds, clearly no oxygen breathed during the run will reach the muscles. The sprint is, therefore, an exuberant and extravagant burning up of energy with a repayment of the debt afterwards, and oxygen is absorbed over a considerable period of time after the exertion. So the limiting factor in this kind of race is some intrinsic quality of muscle — the innate speed at which an athlete can move his limbs. There is also the question of the reflex time — the speed at which an athlete can respond to the starter's pistol. All these factors can be improved, but only a little as they are mainly innate. This is why sprinters are essentially born and not made, and frequently they may run as well as they ever do at the ages of 16, 17 and 18 years; the margin of improvement with age and experience is not great.

Treadmill experiment

In the apparatus we used to study athletes in the Physiology Department at Oxford, UK, the athlete, for convenience, runs on a treadmill, and the slope and speed of the treadmill can be adapted to produce the desired degree of severity of work. The inspired air is fed from cylinders so that the gas mixture can be varied, and a reservoir and sampling tubes enable the gas that the athlete breathes to be sampled. Then from the expired air another sample is taken and the total expired air can be collected in a Douglas bag. There is an automatic sampling device for measuring the level of the gases in the expired air.

Using the apparatus, it is possible to calculate the amount of oxygen an athlete uses above that which he can breathe during a race. Thus it is possible to establish the amount of reliance on the oxygen debt mechanism. A. V. Hill of University College, London, has shown that during a 200 metre sprint, an athlete can take in only a small proportion of the total oxygen requirement, and that he takes most of the oxygen during the long recovery period lasting 30 or 40 minutes. Over longer distances, however, the athlete uses proportionally more of the oxygen he breathes during the race, and the oxygen debt mechanism becomes important only towards the end.

There are several factors involved in the transport of oxygen from the air to the muscles. First the oxygen must be breathed into the lungs and the lungs can become more efficient. Then the oxygen has to traverse a thin membrane, only one cell thick, between the alveolus and the capillary. Experiments done in collaboration with Dr. J. E. Cotes have shown that at higher levels of energy expenditure — at faster speeds of running — an athlete has a higher capacity to transfer oxygen across this membrane than an unathletic subject. The athlete is also able to extract more oxygen from the blood

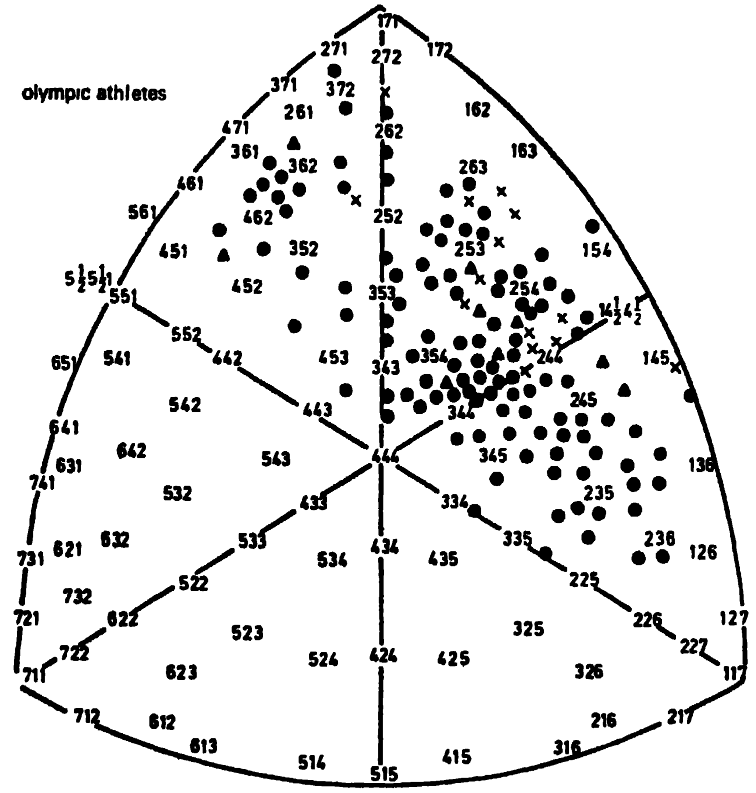


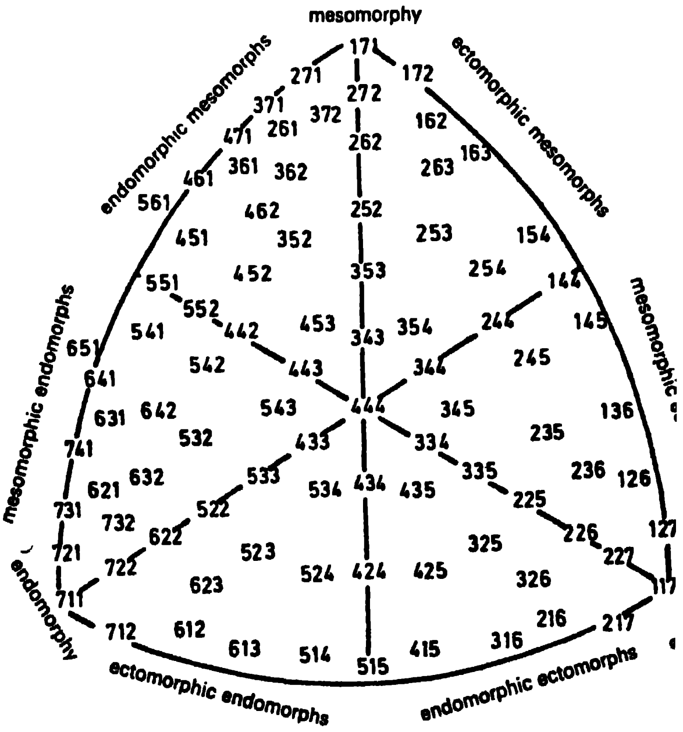
Fig. 1

Physique can be classified into three basic types (fig. 2 below). Endomorphy is the maximum degree of fatness, mesomorphy the maximum degree of muscularity and ectomorphy the maximum degree of thinness. An individual physique can be represented numerically by the number of components of each basic type — the extreme endomorph, for example, being represented by 711. The central point is represented by 444 and in a normal population most individuals are scattered closely around this point. However, the physiques of trained Olympic athletes (fig. 1 left) all have high components of mesomorphy and ectomorphy

than an untrained subject. As a result of training and the improvement of transport mechanisms, the actual supply of oxygen to the muscles during exercise can increase some hundred-fold from the resting level.

New ideas in relation to training developed over the past 20 years have revolutionised the athlete's capacity to transport oxygen. Children, as they are growing, do not exert themselves and then collapse immediately: their lives consist of a series of brief intermittent episodes of exertion. This intermittent strain seems to produce growth and development and so, for an athlete, imposition of the intermittent stress of a mild lack of oxygen can increase the efficiency of oxygen uptake. This principle was first applied by Swedish runners in 1943–44, and Arne Anderson and Gunder Haegg brought the world mile record down to 4 minutes 2 seconds. It was then applied in Germany, and then in England, and it is in this way that athletic performances have improved so considerably since World War II. Athletes trained by running a fast quarter mile, then resting for a while but not long enough to get their breath back completely, and then running for another quarter of a mile and so on.

Fig. 2



One of the most striking exponents of this was the very colourful runner Emil Zatopek (Czechoslovakia), who used to run about 40 quarter miles with a short rest between each one. He told other athletes that on one occasion he had run even more and that he had done this in army boots. The rest of the athletes in the world for some time afterwards gave themselves blisters and shin soreness by trying to imitate Zatopek's feats in army boots!

Gradually the length of time which athletes could train by this method was increased enormously. Jim Ryun (USA), who was 20 years old when he set up the present world mile record of 3 minutes and 51·1 seconds in 1967, has for the past four years been running nearly three hours a day in two, or sometimes three, sessions. One wonders how anyone can devote this amount of time to training and do anything else. The extent of specialisation which is necessary to achieve world record performances is an extremely difficult problem.

What kind of ultimate limits are possible in middle distance running? Bearing in mind the physiological factors that I have mentioned, I could certainly envisage physiologically that the mile could be run in something approaching three-and-a-half minutes although I think it may take 30 or 40 years to achieve this. The length of training would have to increase and athletes would probably have to start training in their teens before their physique had set; in other words, the influence of intermittent oxygen lack would have to be used before their lungs and heart have finished growing. It has always been thought that schoolboys should not indulge in hard serious training, but I think that this concept may not be true.

The marathon

For even longer distance events, other factors apply. In the marathon, a race of 26 miles, 385 yards (42·15 km, the distance from Marathon to Athens), the supply of energy to muscles becomes depleted. The source of energy is glucose, and it has been observed that, at the end of a marathon, runners sometimes reach a state of collapse and the level of sugar in their blood is dramatically reduced. But there is a second factor involved, shown by experiments again done in collaboration with Dr. Cotes. We undertook these in 1961, just before the Empire Games at Cardiff, when there was a suggestion that the marathon might be run in the heat of the day and we were trying to point out that this might not be very sensible.

Athletes performed exercises on a treadmill at two different levels of ambient temperature. Although the higher temperature was not very high, after 15 minutes' exercise in this environment, the athlete's body temperature started to rise higher than during the exercise in the cool environment. It was obvious that body temperature control was adversely affected in the warmer environment, and the athlete had to stop some five minutes sooner than in the cool environment, at the point when the body temperature corresponded to about 104°F (40°C). This is very close to the range where hyperpyrexia occurs (about 105°F). At this point there is a vicious circle, the endogenous heat production within the muscles being higher than the rate at which heat can be dissipated by the conduction, radiation and evaporation of sweat. There are instances of athletes in marathons who have reached this hyperpyrexia range and it would be most unwise for any athletic event of this duration to be held in very hot environments.

HOW THE MILE EVOLVED

The four-minute barrier in the mile race fell in 1954 when Roger Bannister of England ran it in 3 minutes, 59.4 seconds, breaking the previous record of 4 minutes, 1.4 seconds set by Sweden's Gunder Haegg in 1945. The same year, Australia's John Landy clipped another 1.4 seconds off Bannister's record. The following is how the mile record evolved over the past 75 years.

4:15.6	**Thomas Carnaff (US)**	**1895**
4:15.4	**John Paul Jones (US)**	**1911**
4:01.4	**Gunder Haegg (Sweden)**	**1945**
3:59.4	**Roger Bannister (England)**	**1954**
3:58.0	**John Landy (Australia)**	**1954**
3:57.2	**Derek Ibbotson (England)**	**1957**
3:54.5	**Herb Elliott (Australia)**	**1958**
3:54.4	**Peter Snell (N. Zealand)**	**1962**
3:54.1	**Peter Snell**	**1964**
3:53.6	**Michel Jazy (France)**	**1965**
3:51.3	**Jim Ryun (US)**	**1966**
3:51.1	**Jim Ryun**	**1967**

Some may recall the pictures and films of the end of the marathon in the 1954 Empire Games at Vancouver, when Jim Peters (UK) — a truly great marathon runner — reached the final lap in a state of almost complete collapse. He tottered about the track, not really knowing what he was doing until the officials realised the situation and for his own benefit, and I think for the benefit of the sport as a whole, decided to remove him from the track. Fortunately he recovered later in hospital but I am afraid that this situation is a potentially dangerous one.

The use of drugs should be mentioned as one of the other factors which might have an effect on athletic performance. There is insufficient evidence that drugs have been used by athletes, certainly in relation to the conventional athletic events in ordinary athletic contests. And the few scientifically controlled experiments using drugs, such as amphetamines, amytal and placebos, have been rather inconclusive. There was a series of experiments by Professor Beecher at Harvard, USA, in which athletes performed tests which were all timed, standardised and statistically analysed. It seemed that when the athlete supposed that a tablet contained a stimulant he performed very much better, whether the tablet was the placebo or the stimulant. But this lack of true effect may not apply in extremely lengthy events and in the past year or two there have been instances in international events — international cycling events, in particular — in which it has been proven that drugs have been taken. Sport is at the present time organising methods of testing for drugs so that this infringement of athletic and moral law can be prevented.

Limiting factors

Most athletes, I think, realise that besides being morally wrong, it is really the height of folly to imagine that any performance can be consistently improved. Athletes have to compete on many occasions and they must be able to compete within the bounds of their own physical and mental abilities. It is the increased self-knowledge that comes from performance of this kind which forms one of the most useful functions of sport in an educational sense.

I believe that the difference in performance between athletes is not merely due to differences in physique, cardiac output or capacity to transfer oxygen. It is due more to the capacity for mental excitement, which is largely inborn and which brings with it the capacity to ignore or overcome the discomfort and pain in the brain and muscles, caused by the lack of oxygen. Although physiological and circulatory limits to muscular exercise may be important, it is psychological factors beyond the ken of physiology which set this razor's edge between defeat and victory and which determine how closely an athlete comes to the absolute limits of performance.

This mind-body relationship is extremely difficult to understand, and I might perhaps best illustrate it with a story which is told about Zatopek. In the Helsinki Olympic Games in 1948, Zatopek was running his first marathon, having already won the 5,000 metres event and the 10,000 metres event. After about 16 km he was running just behind the English marathon runner, Peters. In his very good English he said, " Excuse me, Peters, but I have not run a marathon before and surely we should be going faster than this? " Peters carried on running for another two or three hundred metres at his normal speed but was then overcome by a tremendous weariness. Zatopek increased his speed, but not for long, and was able to continue and win the event comfortably.

Mexico Games

The decision to hold the last Olympic Games in Mexico City, at 2,250 metres above sea-level, was astonishing. The consequences of holding the games at such an altitude where the atmospheric pressure of the air is reduced by a quarter are fairly obvious, I think, from the points already made. Performance in all distance events from 200 metres upwards is dependent on the capacity of the athlete to transport oxygen to his muscles, and if the amount of oxygen in the outside air is reduced, then performance must suffer.

The observed effect of altitude varies with the distance of the race run. In the 800 metres event, the reduction in the oxygen tension was more than balanced by the reduced air resistance and a new world record was achieved by an Australian athlete. In the 1,500 metres race, in which only 25 per cent of the energy for running comes from an anaerobic debt mechanism, the Kenyan athlete Kipchoge Keino won easily from the world record holder, Jim Ryun, who had twice defeated Keino at sea-level. In the 5,000 metres, Gammoudi, a Tunisian who lived and competed at altitude for four years prior to the Mexico Olympics, won and was followed by Keino and Temu of Kenya. The sea-level runners found that any slight oxygen debt accumulated early in the race could not be eliminated and many finished the race only to collapse unconscious at the finish, overcome by a form of syncope. There were similar unhappy endings to the 10,000 metres, the 3,000 metres steeplechase and the 3,000 metres cross country run in the pentathlon event. In some instances the athletes described visual impairment before collapse. But the occurrence of these ill-effects was overlooked by the Mexican medical authorities and this aspect of the Games will probably be completely expunged from the official

New Zealand's Peter Snell (left) finishing the mile in a record-breaking 3 minutes, 54.4 seconds in 1962 in New Zealand; he improved this record 2 years later. In the centre is Jim Ryun (USA), the current mile record (3 minutes, 51.1 seconds) holder, and at right is Ron Clarke, the Australian Olympic long distance runner

Olympic records. It would be unfortunate if public memories were so short that international events could ever again be held at altitude.

But in many ways the Mexico Games were most successful. There was an astonishing total of 15 world records broken in sprinting and jumping events and this is truly amazing, even taking account of the thin air which gave an ' advantage ' in these events. The 100 metres final was an all-Negro affair resulting in a new Olympic record of 9·9 seconds. And new Olympic records were set in the 200 metres, 400 metres, 400 metres relay, 1,600 metres relay and the 400 metres hurdles event. But these records raise a problem for the administrators. It will be a long time before many of them are equalled at sea-level and there is already a move to put them in an entirely separate record book bearing the title " Mexico City ".

Can any sea-level athlete ever acclimatise to altitude? To acclimatise completely, an athlete must choose his parents carefully and be born at altitude. The ' one month altitude training ' rule, belatedly introduced by the International Olympics Committee, was ridiculous because it could not be enforced and was merely a gesture towards recognition that a problem existed. Sea-level runners with up to two years' altitude training collapsed at the tape while Kenyans and Ethiopians just continued running up the ramp that leads out of the stadium with an almost contemptuous ease. The exact physiological advantage of the altitude runners has not yet been established but they appear to be able to extract more oxygen from their blood than sea-level born athletes, no matter how long the latter have been acclimatising at altitude.

So we now face the immediate situation in which altitude has opened a kind of Pandora's Box of problems. How amateur can the distance runner of the future be if he must find some way of living most of the year at altitude? Perhaps he needs a special identity card registering him as a runner at a certain level! Future complications are limitless.

Proton Decay

A TEAM of British, American and Canadian physicists under the leadership of an American, Dr. Joseph Cerny, associate professor of chemistry, University of California, Berkeley, USA, has discovered an entirely new way in which a chemical element can be transmuted to another by the process of radioactive decay. In true scientific fashion, this discovery was a result of the exploitation of chance situations. The newly observed mode of decay involves the emission of a proton by an unstable nucleus, and is called proton decay. An extraordinary feature of the discovery is that direct proton decay, long predicted to occur in highly unstable nuclei, has been observed in relatively stable radioactive nuclei of cobalt.

For the last 30 years, nuclear physicists have known of three ways in which a nucleus can be transmuted by radioactive decay. At the turn of the century, Lord Rutherford identified the types of break-up of the nucleus called alpha and beta decay, in which alpha particles and electrons respectively are ejected as the nucleus falls apart. In 1940, a third decay process was reported in which the nucleus breaks up of its own accord in spontaneous fission. The possibility of observing direct proton decay has recently excited a lot of interest particularly among Soviet physicists. But calculations have predicted that this fourth form of decay could only occur in very unstable nuclei which cannot be produced by the presently available nuclear particle accelerators. In effect, it was predicted that for proton decay to occur, the amalgam of protons and neutrons that make up the nucleus must be severely depleted in neutrons.

According to Dr. Cerny and his colleagues (*Physics Letters*, 33, 26 October 1970), they were first alerted to the possibility of observing proton decay during experiments at the Atomic Energy Research Establishment at Harwell in England. They were studying the interaction of calcium nuclei with a beam of oxygen nuclei produced by the variable energy heavy-ion cyclotron at Harwell when they found, to their surprise, that protons were being produced in the nuclear reaction. Although they were trying to produce nuclei of nickel, when the nuclei of calcium and oxygen merged, one proton and two neutrons were emitted leaving behind a specially distorted nucleus of cobalt-53. This cobalt nucleus then decayed by the new process of proton decay into iron-52.

The experiments in England, however, were not conclusive. There were two questions outstanding. For one thing, the reaction between a large nucleus like oxygen with calcium is complicated, and the task of picking out all the resultant individual particles is arduous and confusing. For another, it was not feasible to rule out the phenomenon called beta-delayed proton emission in which the fundamental decay mode of the radioactive nucleus is the known beta-decay, and the proton is ejected from the excited nucleus only as a secondary process.

Conclusive evidence for the fourth mode of decay was obtained last summer by Dr. Cerny and his colleagues, Drs. J. E. Estrel, R. G. Sextro and R. A. Gough, at the University of California's Lawrence Radiation Laboratory at Berkeley, USA. In the new set of experiments, they bombarded iron-54 nuclei with protons from the 88-inch (220 cm) cyclotron in Berkeley. In this reaction, two neutrons were again emitted, yielding the same excited nucleus of cobalt-53. They succeeded in observing clearly and unequivocally, the direct emission of protons by switching the proton beam of the cyclotron on and off for periods of about a second. Those protons detected in the 'off' periods must have come from the short-lived cobalt nuclei by the process of proton decay.

How Bats Measure Distance

THE ears of bats play a unique part in the avoidance of obstacles during flight. For locating the obstacle and its distance, some insectivorous bats emit sound pulses of different frequency and amplitude. Echoes coming back from objects at different places overlap and show complex envelopes and structures which are quite different from those of the outgoing sounds. The ears of bats are provided with a highly specialised radar system to analyse these complex echoes for locating the obstacles as well as to measure their distances.

Bats measure the distance to an object in terms of the time lag between their outgoing orientation sounds and the returning echo. This time lag is coded in the difference in time between the response of a neuron or nerve cell to the outgoing sound and to that of the echo. A series of tests on live bats by Dr. N. Suga, of the Department of Biology, Washington University, St. Louis, Missouri, USA, has now revealed that bats have neurones that are specialised for echo ranging, and these are situated in a part of the hearing system known as the inferior colliculus.

For a neuron to act as a rangefinder, it must feed the brain with electrical pulses to coincide with both the outgoing signal from the bat and the echo. These pulses must occur only once within what may be a quite blurred out signal, and must occur at the same instant independent of how deformed the sound may be in the echo. If a neuron produced several pulses for an individual echo, it is valueless as a rangefinding device as the bat would be unable to distinguish between multiple weak echoes and a single strong one. These factors have helped Dr. Suga to narrow down, before the experiment, that part of the hearing system in which the specialised echo-ranging neurones were likely to operate.

In his experiments described in *Science* (*170*, 449, 23 October 1970), the American zoologist used the species of bats known as *Myotis lucifugus* and *Myotis sodalis*. The bats were anesthetised with phenobarbital sodium and mounted on a small platform in a sound-proofed room in which the temperature was maintained at about 35°C. A small hole was made in the skull covering the inferior colliculus, an electrode was inserted into the colliculus through the hole, and sound stimuli were delivered at a rate of two per second from a loudspeaker located 68 cm in front of the head.

Dr. Suga studied the responses of 57 inferior collicular neurones to the sound stimuli. He found that less than 20 per cent of the neurones he studied had a response suitable for range finding. This small number was recognised by the way the electrical response remained unchanged for different types of echoes and signals, and by the fact that only single pulses of electricity were produced for each echo.

Test-Tube Mice

FULLY developed mice offspring have been obtained for the first time from eggs artificially fertilised outside the body. This is the remarkable achievement of two embryologists, Dr. A. B. Mukherjee and Dr. M. M. Cohen of the State University of New York at the Department of Pediatrics, Buffalo Medical School, Buffalo, New York, USA. How they accomplished this feat is described in *Nature* (*228*, 472, 31 October 1970).

" Test-tube embryos "—a child conceived out of the body in the laboratory—have been much publicised recently. The method involves the removal of the female egg from the ovary, fertilisation in the laboratory and replacement of the egg in the woman's womb (See SCIENCE TODAY, July 1970).

In the case of humans, only the first part of the experiment, namely, the fertilisation of the egg outside the uterus, has so far been successful. This was achieved about two years ago by Drs. R. G. Edwards, B. D. Bavister and P. C. Steptoe. They matured and fertilised human oocytes, the precursors of the egg cell, in special culture media supplemented with foetal calf serum. They observed the fertilised egg to divide itself into two and then into four. However, only when the egg has developed outside the body to a stage known as the blastocyst stage will it be possible to return the egg to the uterus for the growth of the normal foetus. Experiments in this direction are now in progress, and there are reports that fertilised eggs have been observed developing as far as the 64 cell stage.

Eggs of several other mammalian species like hamsters and rabbits have also recently been fertilised outside the body, but only in the case of mice has it been possible to continue the development to the blastocyst stage, and implant them back into the uterus. However, in the previous attempt with mice by D. G. Whittingham (*Nature*, *220*, 592, 1968), the foetuses produced by implantation had failed to survive for more than 17 days.

In their experiments, Drs. Mukherjee and Cohen removed large numbers of eggs from the ovaries of mother mice after subjecting them to super-ovulation by intraperitoneal injections. These eggs were then transferred to a culture medium containing sodium pyruvate. The eggs were fertilised in the laboratory by mixing and incubating them with mouse sperm extracted from the uteri of other females after they had been mated with a proven fertile male. The fertilised egg cells underwent the series of divisions till the blastocyst stage was formed. At this point, they used an ingenious device to overcome some of the difficulties encountered by other workers in the implantation of the developed egg in the uterus of the mother mouse. They used pregnant mice as foster mothers.

Of 253 eggs exposed to the sperms, 67 were fertilised, and of them 25 developed to the blastocyst stage. Twenty three of these blastocysts were surgically implanted in the uteri of pseudo-pregnant or normally pregnant female mice, and 11 apparently normal offspring developed. They could be distinguished from the natural offspring of their foster mothers by their different coat colour.

The significance of these experiments is that it provides a means of inducing children in a small number of women who are at present sterile because their fallopian tubes are damaged. When the fallopian tubes between the ovary and uterus are blocked or damaged, eggs cannot be released and fertilised. The new technique will enable such women to bear their own children, fathered by their husbands, in a test-tube.

K. A. Neelakantan

THE KILLER WAVES

Hardly ever 'tidal', more often the frenzy of the wind

THE association is as ancient as the mariner, but man has yet to get over his awe of the sea. And mysterious the ocean is. A playful spray can turn into a nightmarish tempest. Tidal waves reach up to the skies and toss ships like little toys on their mighty mane. Tidal waves? Are these the killer waves that men refer to with awe and fear? To be precise, they are not. A tidal wave is merely the tide regarded as a wave, following the Sun and the Moon from the east to the west.

Then what are these giant waves? They may be born under a variety of circumstances; often the product of already existent natural disasters, they include tsunamis and the storm surges of cyclones.

Tsunami is a Japanese word originally meaning harbour waves. It's quite an apt derivation since a tsunami causes extensive damage in ports. This word was coined to replace ' tidal waves ' — a misnomer till then in common usage.

A tsunami is a series of waves caused by the movement of the sea bed. It can be caused in any of three ways — by vertical deformation of the sea bed along an earthquake fault, by a submarine landslide or by a submarine volcanic eruption.

The Pacific, for example, is ringed with earthquake zones, many centred in submarine trenches. These trenches, often up to 5 km in depth, are the birthplace of many of the largest tsunamis. Not all earthquakes, however, generate tsunamis.

Whether tsunamis can also be generated by submarine landslides is still a matter for speculation. Yet the possibility has been favoured by several scientists after they studied tsunamis generated by earthquakes whose epicentres lay on the land. But further observations will be necessary before a conclusive proof is arrived at. The third type, tsunamis generated by volcanic eruptions, is extremely rare.

Sea bed movements cause oscillations on the surface before equilibrium is attained. These oscillations cause waves. It's like throwing a pebble into water; ripples move from the point of impact towards the shores. It is naturally impossible to study submarine earthquakes directly. However, indirect observations are possible and several studies have revealed interesting connections between earthquakes and tsunamis. They have implied that there is an empirical connection between the magnitude and focal depth of an earthquake and the tsunami height. Secondly, earthquakes, whose epicentres lie at great depths, generate tsunamis with greater heights than those having epicentres in shallow water. Another derivation arrived at is that tsunami energy is directly proportional to the total energy of the generating earthquake. Even though only a one per cent fraction of the earthquake energy is converted into tsunami energy, this may total about 3,000 million kilowatt hours or the equivalent of a 2·5 megaton nuclear weapon.

By studying the heights and periods of a Pacific tsunami in 1957, it was possible to arrive at a theoretical calculation of the probable size and shape of the sea bed movement. The conclusion: a volume of $2 \cdot 3 \times 10^{10}$ cubic metres subsided 80 metres in a matter of seconds.

The tsunami wavespeed depends on the ocean depth—the greater the depth, the faster they travel. In mid-ocean they reach velocities of about 800 kmph. As ocean depths are known, it is possible to compute the arrival time of a tsunami at a given place by calculating its probable speed. This helps immensely in tsunami warning.

Wave form and energy

Tsunami waves have long periods — from ten minutes upward. The wave pattern of the initial tsunami is governed by the size and shape of the source disturbance. However, it undergoes changes as it moves away from its origin. It starts as a few simple waves — and ends in a complex of many waves. If the original disturbance is an earthquake, the lead feature of the wave form will be a crest. A volcanic eruption would cause an initial trough. The highest wave is the first, but its position in the wave train moves progressively backwards. These features make tsunamis absolutely dangerous to the uninformed. A trough would lead the curious out to investigate. They'd be inundated in the crest that follows. A crest would destroy property, and then lull people into a false security that the worst is over. After some time another crest follows causing further destruction.

As tsunamis are practically frictionless, they can travel thousands of kilometres without losing their energy. The Chilean tsunami of 1960, travelled 16,000 km over the ocean, hitting Hawaii and far off Japan. The Japanese didn't expect the waves to be as destructive in Japan as they were in Hawaii. They were mistaken — they paid dearly for their complacency.

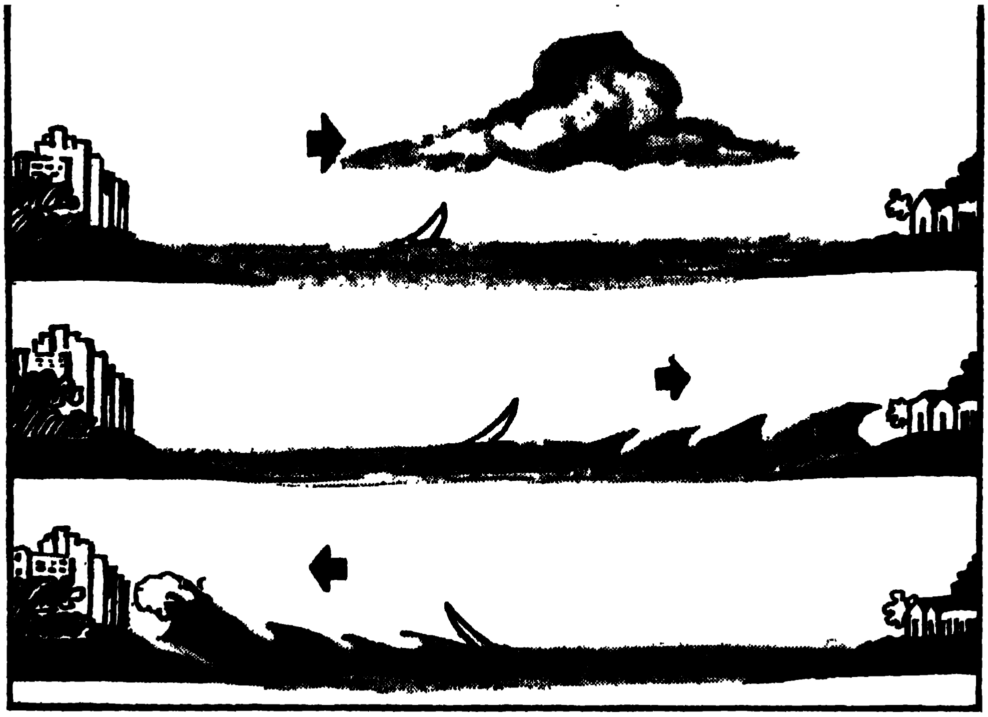
When a tsunami spreads, its concentration of energy is spread over a greater area. The situation reverses suddenly at the shoreline. The velocity decreases in shallow water. The energy gets concentrated. Consequently the wave height increases.

Tsunamis lose two-thirds of their energy every 12 hours. Their effects, however, persist for as long as a week before the sea finally returns to its normal level. This slow decay is due to reflections by underwater slopes. About one-third of the energy is reflected when a tsunami moves from the deep ocean to the continental shelf.

Shoreline features, too, play an important part in moulding the tsunami that eventually invades the land. A sloping sea bottom increases friction, thereby diminishing the energy of the tsunami. Valleys, too, disperse waves and spread their energy. Conversely, ridges refract waves and concentrate their energy. Big islands face the highest waves and divide them. When they reunite, their height again increases. In estuaries, tsunamis are funnelled into a bore. In bays they initiate sieching, an effect similar to water in a bath sloshing from end to end. This generates currents of up to 19 knots (10 kmph) — and may rip ships from their moorings and smash them against the quayside or on warehouses. That's why tsunamis are especially dangerous in harbours.

Tsunamis are more frequently seen along the Pacific, although the Mediterranean too has had its share. The Atlantic has them very rarely. Japan holds the most unenviable record of tsunami disasters. On an average, a tsunami of over 7·5 metres hits Japan every 15 years. One over 30 metres hits it every 300 years. South America too is tsunami-prone though the northern continent has been graciously spared.

An ancient monument in Japan holds the wise inscription: "When you feel an earthquake, expect a tsunami." Yet, strangely it was only in 1946 that a tsunami warning system was set up there. This consists of networks of seismograph and tide gauge stations around the Pacific seaboard with the central station in Honolulu. If the epicentre of a quake is submarine, the tide gauge stations nearest to it are alerted. If abnormal wave activity exists, general warnings of estimated times of arrival of the tsunami



The formation of a reflected wave in an inland body of water

are transmitted to local authorities in vulnerable regions. The Japanese have planted trees, built walls, evacuated villages to higher ground. Yet somehow there seems to be no way of getting away from it.

As tsunamis travel at high speeds, adequate warnings cannot be given. A possible solution to this lies in the earthquakes themselves. They generate T-phases (sound waves in the sea). These travel at about 7 times the speed of tsunamis. A peculiar phenomenon caused by temperature and pressure gradients in the ocean channelise the sound — ' deep sound channels ' centred at about 400 metres in which the T-phases are conducted with little attenuation. Hydrophones placed in these channels could pick up and transmit the warning well in advance of the arrival of the tsunami itself.

A ship was once ploughing through waves about 9 metres high. Suddenly a wave hit its superstructure, 24 metres above the waterline! If rough seas and waves persist long enough, one in 20 waves will be a killer wave, as much as 2·2 times higher than the average. In 1933, a ship was hit by a wind wave 34 metres high!

Wind waves must not be confused with storm waves. It is true storms generate high winds. But winds can exist outside a storm. Winds as low as 6 kmph can create waves. But velocity is not all. Other factors include the duration of the wind and the distance over which it can act on the surface of water — this is called ' fetch ' by seafarers.

Wind waves are basically of two kinds — sea waves and swells. Sea waves are a confused mass of waves of different shapes and sizes, running into and past one another. They occur in the vicinity of storms. The brisk wind blows the tops off the steeper waves, producing whitecaps.

Separate the waves from the storm that produced them and you get a swell. Swells go on regularly, in undulating patterns, till they pound the distant shores and spill their foam on the beaches. An Antarctic storm produced swells that moved across the Pacific and broke on the coast of Alaska two weeks later.

There's another type of killer waves — the reflected ones. This is one wave that has nothing to do with the open sea. They are produced in inland bodies of water. Like tsunamis in a harbour, reflected waves have the same sloshing effect on the enclosed body of water. Lake Michigan in the US experienced such a wave in 1954. A squall line moving with the right combination of air pressure and wind effect from west to east hit the southeastern shore. On its way back, because it had nowhere else to go, the powerful wave hit the shores of Chicago, taking people by surprise — and killing quite a few.

Sieches are not reflected waves. Though they are produced in a similar way, their effect is different. The water continues to rock back and forth from shore to shore, endlessly. Lake Erie in America has sieches. It's long and narrow profile, along with prevailing winds, makes it the ideal setting for sieches.

. . . and winds too

The greatest danger, however, comes with cyclones. Cyclonic storms can whip up winds to tremendous speeds and when they reach the shores, the swells inundate the land in a huge solid mass of water.

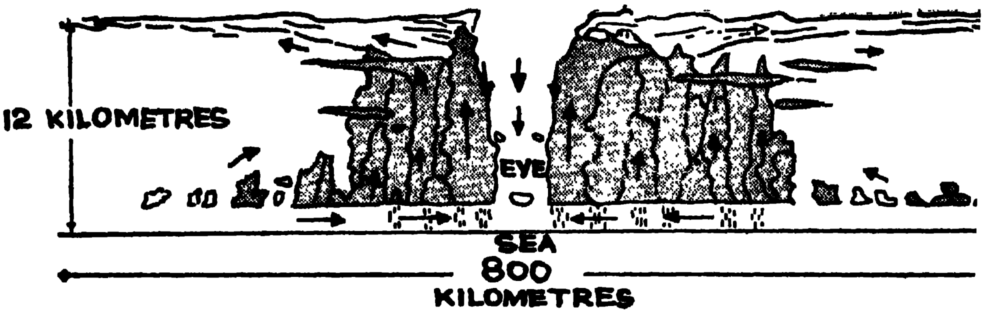
The word cyclone comes from the Greek root words 'kuklos' (circle) and 'kykloein' (whirling). The dictionary defines a cyclone as a low pressure storm area into which air spirals, usually forming clouds and precipitations. But there is much more to cyclones than that.

There are three types of cyclones. The largest is the frontal cyclone — this reaches up to 1,600 km in diameter. The smallest is the tornado — about 90 to 180 metres wide. (On the sea, the tornado takes the form of a waterspout.) In between falls the hurricane or typhoon — this is about 80 to 800 km across.

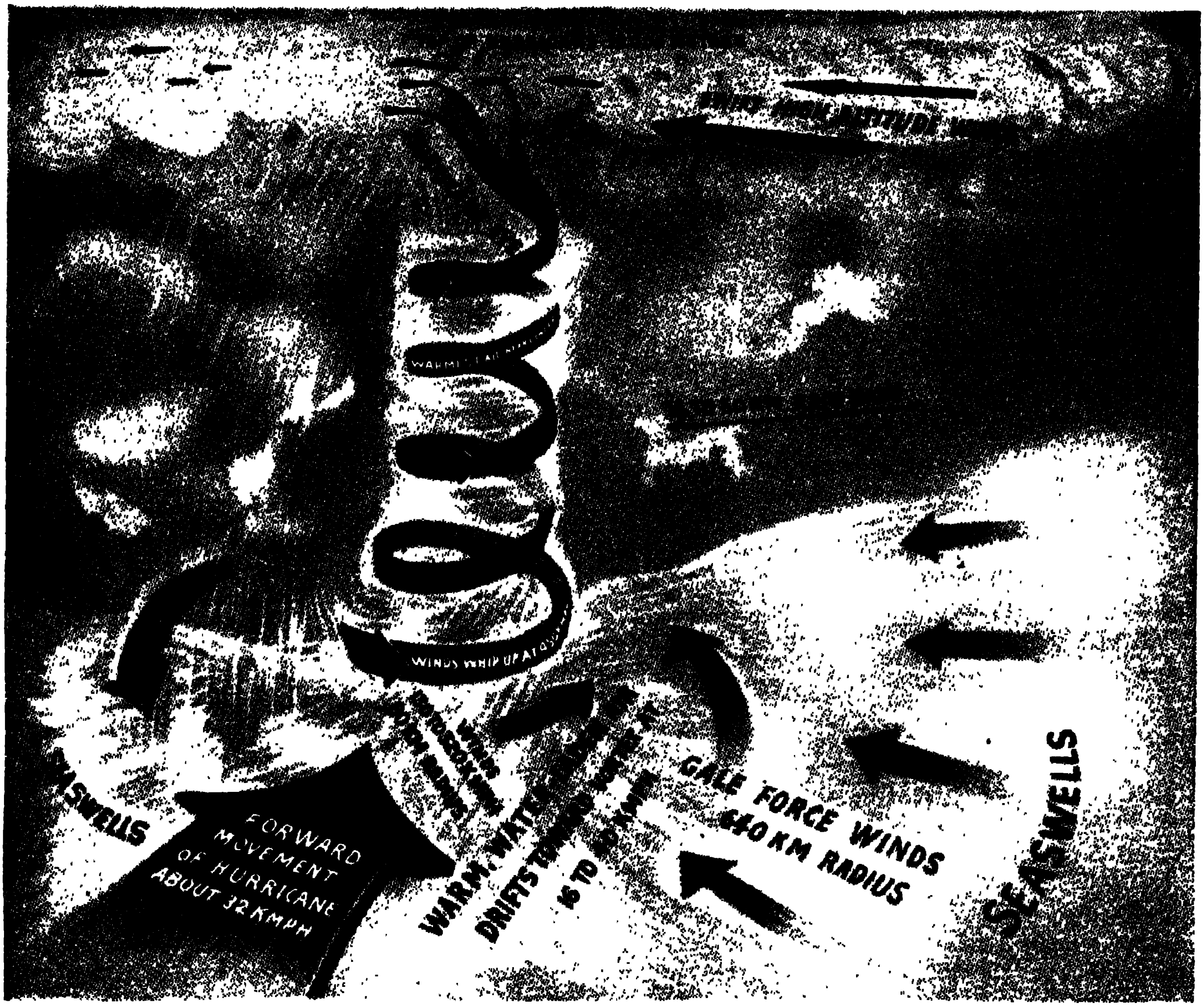
What creates a cyclone? The Earth rotates on its axis. This means air masses, too, rotate at the same speed. If we were to draw a vertical line above the north and south poles, we would see that air at the north pole rotates in a clockwise direction while at the south pole its direction is anticlockwise. When air masses move horizontally from the poles toward the equator, they are subjected to a strange phenomenon — the Coriolis effect. If we consider the rotation of the Earth, we know that a point near the north or south pole moves much slower than a point on the equator. If a person moves in a straight line from the pole to the equator, he gradually moves from points of lower velocity to points of higher velocity. Thus he moves, not in a straight line, but in an arc. If he goes back, he again moves in an arc, this time in the opposite direction. So if he moves from pole to equator and back again, his path completes a circle. This circle is anticlockwise in the northern hemisphere and clockwise in the southern.

Air moving toward the equator also goes through this phenomenon. And air does move toward the equator because the equator is a low pressure area. If the air passes over large expanses of water, it soaks up water vapour and heat. It drifts sluggishly at first, then picks up speed. The warm air rises. Cold air converges to fill the gap. The Earth's rotation causes the air to spiral inwards. The warm air, and the clouds it forms, pick up speed as they move to the spiral's centre. At the vortex, the air rises skyward and spreads out in great sheets of rain clouds. The expansion cools the air and rain falls. The expansion of air causes a decrease in the rate of rotation so that, at the start, there is an anticyclone rotating in the opposite direction relative to the Earth at high levels above the new cyclones. The cold air converging in can alternatively be considered as an area of high pressure. This condition is reversed at the top where the warm air disperses. The vortex is the high pressure area at the top.

Rain is the cyclone's fuel. The spiralling wind absorbs moisture as it travels over the ocean. This moisture vaporises and as it rises it condenses into rain, releasing heat which warms the spiralling cloud column, boosting its air upward as high as 12 km. The quantity of heat released by the rain is so great that the eye of the cyclone is as much as 10° to 15° colder than the surrounding air. High speed wind movements at a high altitude are essential to give a cyclone a longer lease of life. These winds carry the air at the top of the spiral away. If they did not, the cyclone would choke and die — it would be like closing the top of a chimney. A cyclone now looks like an inverted whirpool. The winds may reach speeds up to 120 kmph. They churn sea water into a fine spray making its evaporation easier and thus feeding the cyclone further.



A cross-section of a hurricane, showing the cloud arrangement around the eye. The arrows show the air movements


SWELLS
FORWARD MOVEMENT OF HURRICANE ABOUT 32 KMPH
GALE FORCE WINDS 640 KM RADIUS
SEA SWELLS

The anatomy of a hurricane (Based on a sketch from *Popular Mechanics*, September 1968)

A frontal cyclone, as mentioned earlier, is spread over a large area. It forms on the boundary of cold polar air and moist, warm tropical air. The cold air goes under the warm air and lifts it. The warm air condenses and large areas of rain and snow are produced. All cyclones need a central vortex of low pressure. In frontal cyclones, this is provided by a wedge of warm air that is drawn into the centre of the spiral.

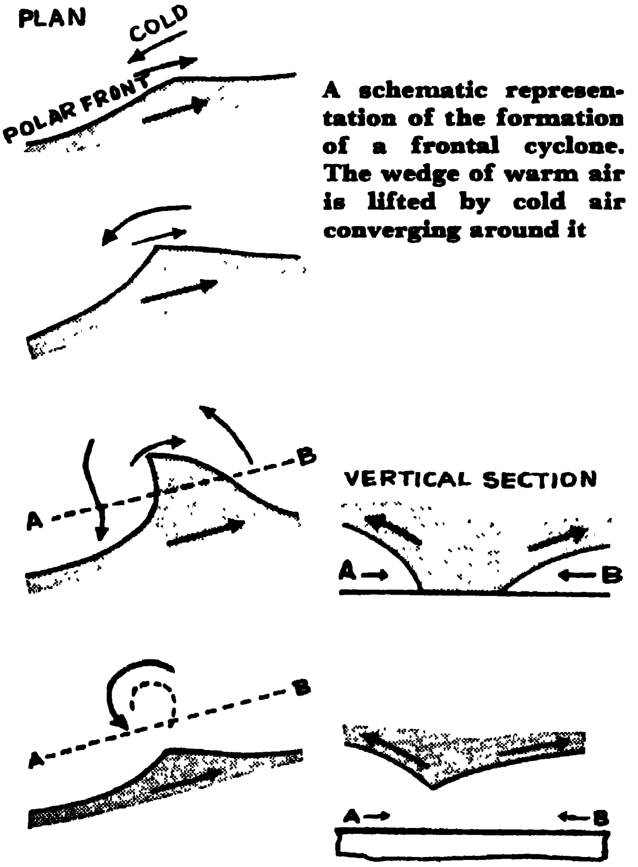
In tornadoes, the low pressure area in the centre comes from a body of air drawn from a single shower cloud. The rapid condensation of water droplets releases enough latent heat to sustain a tornado. This also provides the strong updraught at the centre to enable cold air to converge horizontally. The rate of rotation is such that the force toward the low pressure area counterbalances the centrifugal force.

Tropical cyclones are the most destructive in this category. It's because they produce heavy rains and floods, very strong winds and often even tidal waves — at the same time. These tropical cyclones have different names. They are hurricanes in the Atlantic, typhoons in the Pacific, willie willies in Australia and an exotic 'baguios' in the Philippines. They mean the same — cyclonic storms. The etymology of these words is fascinating. Tornado comes from Spanish — it means turning. Hurricane derives from Hunraken —the Mayan storm god. Typhoons have many origins. In Greek mythology, Typhon was the father of dangerous winds. In Chinese there's a word Taifung — it means great wind. In Persian we have *tufan* — means almost the same. Hurricanes, typhoons — call them anything — are deadly killers. It was estimated a few years back that a mature hurricane gulped one million metric tons of water each second. The estimate is wrong. The actual figure is about four times greater. Another estimate shows that a medium-sized cyclone, in a single day, releases through condensation as much energy as the simultaneous explosion of 400 20-megaton hydrogen bombs. The water spirals up the centre at close to 480 kmph.

Typhoons are more dangerous than the dangerous hurricanes. This is because they travel over vast expanses of water before striking land. That's time enough for them to rev up to greater heights. An aircraft carrier with a flight deck five stories high, ploughing through a typhoon, had waves lashing over it. The wildest winds lie within 80 km of the eye. After that the winds just drop; the change is so abrupt that a half-kilometre difference can cause some houses to be smashed while others just suffer broken panes.

The equator has no hurricanes; there is no Coriolis effect there. The winds have to be at least 500 km from the equator. But not much further, because the water needs to be at least 85° warm. If you satisfy these conditions you have a hurricane within 24 hours. If not, if the Coriolis force is weaker, the hurricane takes several days to brew.

Dry land or cold water spells death for a hurricane. It does not get its fuel supply. On warm water, a hurricane can last from a few days to a month before a shift in tropospheric winds or atmospheric pressure kills it. The travelling speed may be 19 to 22 kmph — but many a time it may touch 96 kmph.



A schematic representation of the formation of a frontal cyclone. The wedge of warm air is lifted by cold air converging around it

WHAT THEY MEAN....

Cyclone: A low pressure storm area into which air spirals, usually forming clouds and precipitations.

Anticyclone: A high pressure area from which air spirals outward.

Gale: Winds from 62 to 118 kmph; strong gale: winds from 75 to 86 kmph; storm: winds from 88 to 100 kmph; violent storm: winds from 102 to 118 kmph.

Hurricane: A tropical cyclone with winds above 118 kmph.

Typhoon: A Pacific cyclone.

Hurricanes follow whimsical routes — their path of destruction is decided by seasonal winds and giant high and low pressure systems. Trade winds nudge them to the land. High pressure regions cause them to veer on an erratic course — much to the vexation of meteorologists — making their course predictable for a mere 24 hours in advance.

Hurricanes develop swells which travel at speeds of about 48 kmph. The storm surge is the most feared — even more feared than the hurricane itself. The low pressure area at the hurricane's centre sucks the sea up about 30 cm. Winds lift the water an additional 3 metres. Add this to a high tide area — you get a veritable tidal wave advancing on the land — a sea wall over 6 metres high. Remember the catastrophes caused by storm surges? Calcutta lost 3,00,000 people in 1737, East Pakistan lost 2,00,000 in 1970.

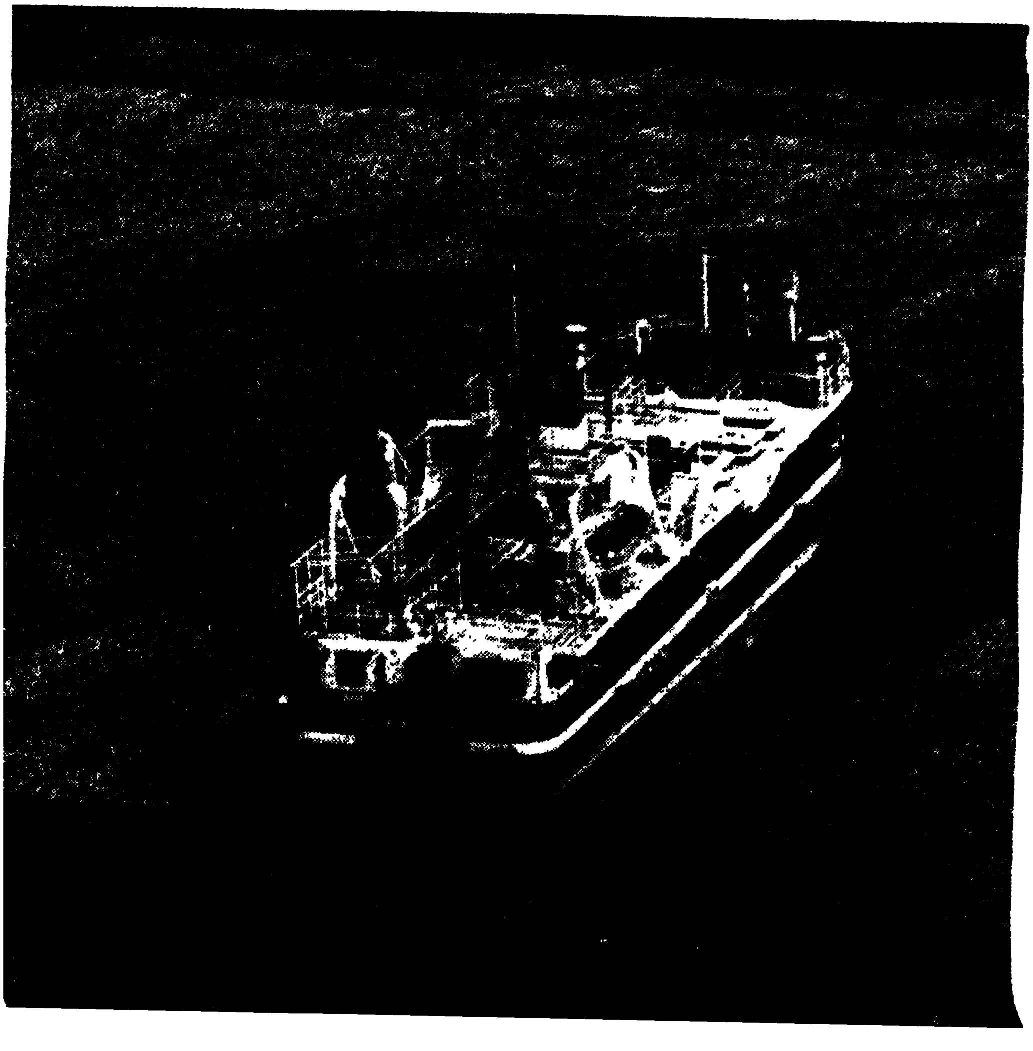
How do we predict hurricanes? If prediction is difficult, is there a way to fight hurricanes — to knock out their eye teeth. That is as yet impossible. But a weapon exists that helps abate a hurricane's fury — silver iodide bombs. A hurricane's wind force is a measure of the barometric difference between the low pressure centre and the high-pressure outskirts. The greater the difference, the greater the amount of water sucked up. Silver iodide bombs give out nuclei which cool vapour and condense it to raindrops. Latent heat is released. It warms the air, causing it to rise. The barometric pressure drops well behind the vortex. The hurricane doesn't drop dead. It abates its fury.

Now with weather satellites, there's hope for a more streamlined and comprehensive forecast system — and more hope for studying in greater detail the mechanisms of cyclones.

PAKISTAN'S BLACK FRIDAY

12 NOVEMBER 1970

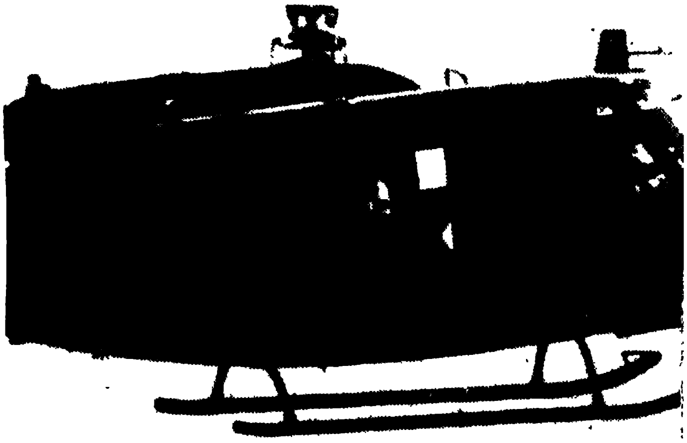
A steamer washed ashor

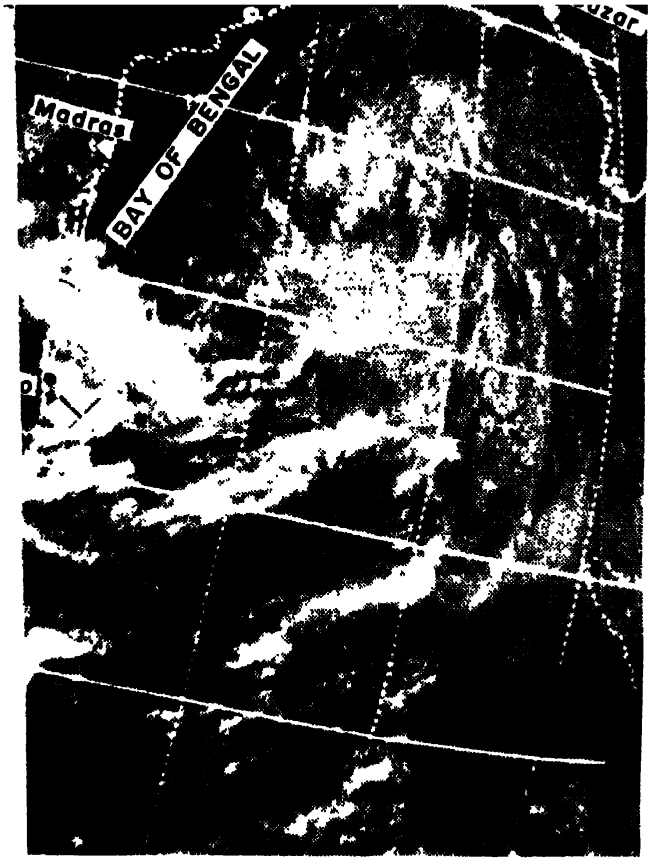


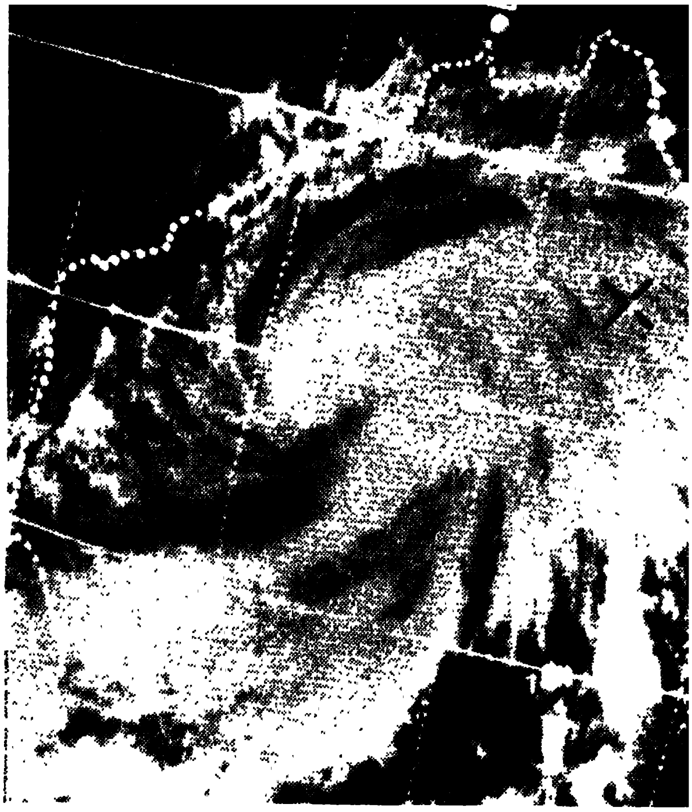
A bridge destroyed

Corpses of cattle and people

Supplies a





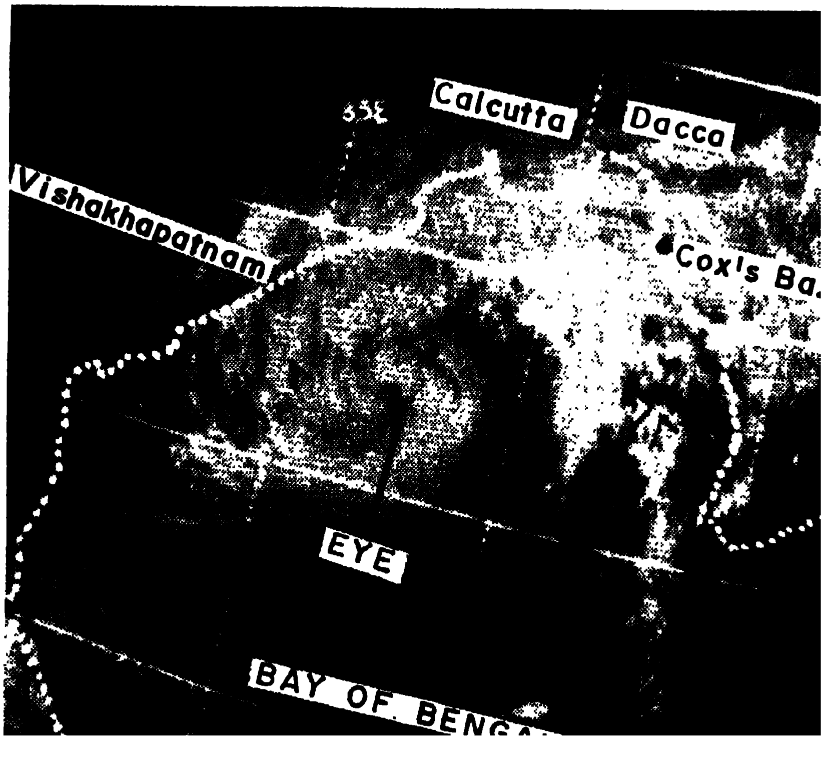


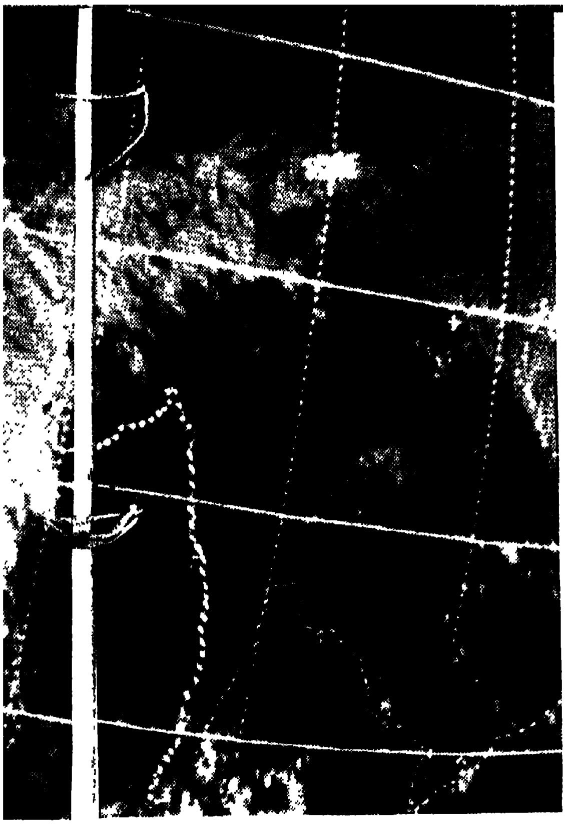
1. (Above, left) Nov. 8. Orbit No. 3614; time: 15h 26m IST. Unsettled weather conditions in the Bay of Bengal; ships' observations meagre. Well-marked low pressure area; a cyclone is born

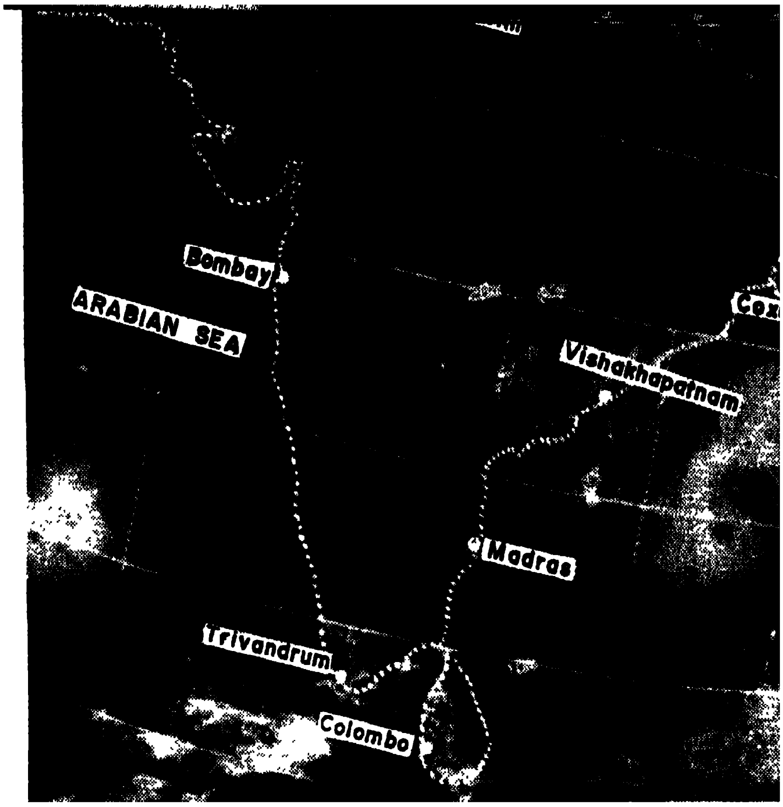
THE BIRTH AND DEATH OF A CYCLONE

October and November are dreaded months in the Bay of Bengal. Cyclonic storms whip up the seas and generate tidal waves that ravage the land.

These photographs were taken by the US weather satellite, mproved TIROS Observation Satellite (ITOS-1). They depict graphically the birth and death of the epoch-making cyclonic storm that devastated East Pakistan on 12 November 1970





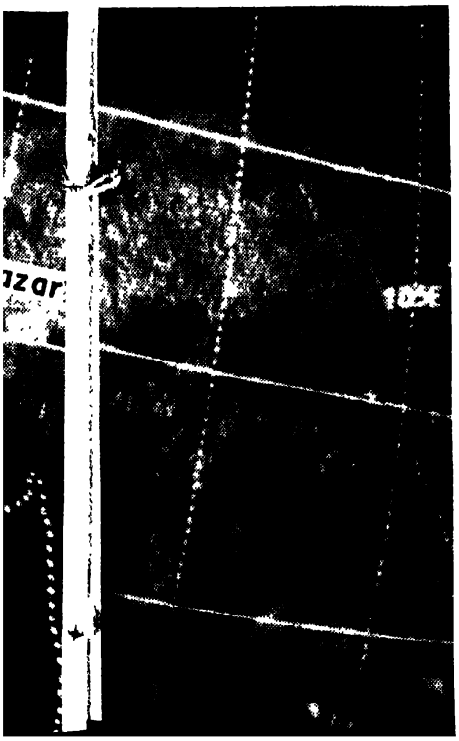


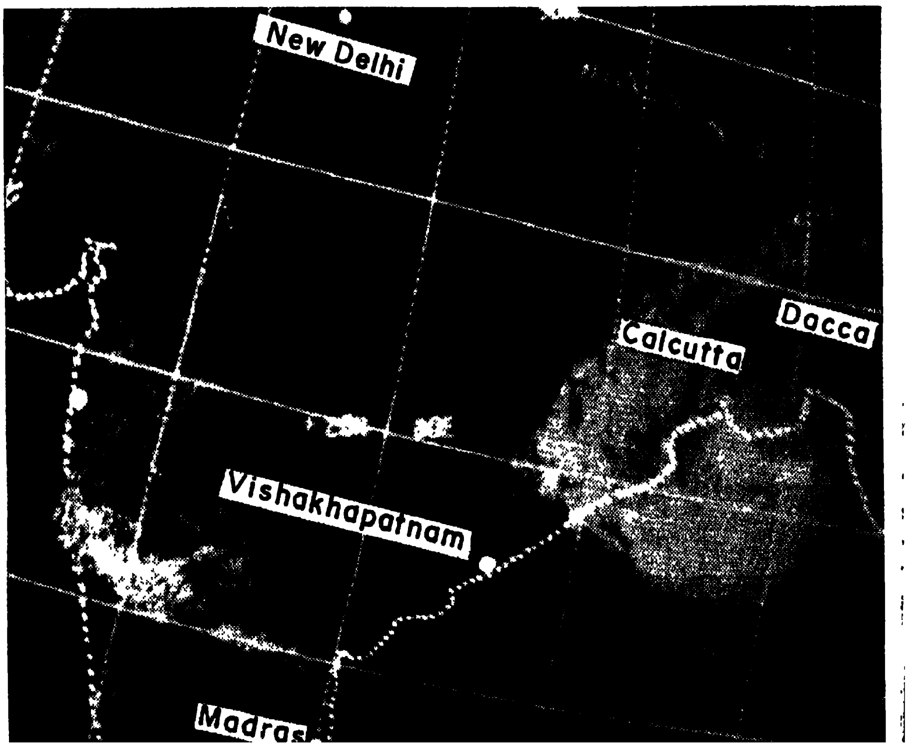
2. (Above, centre) Nov. 9. Orbit No. 3626; time: 14h 39m IST. The cyclone takes shape and an "eye" is seen forming. The clouds canopy almost the whole of the Bay of Bengal; in fact they extend into China in thinner streams

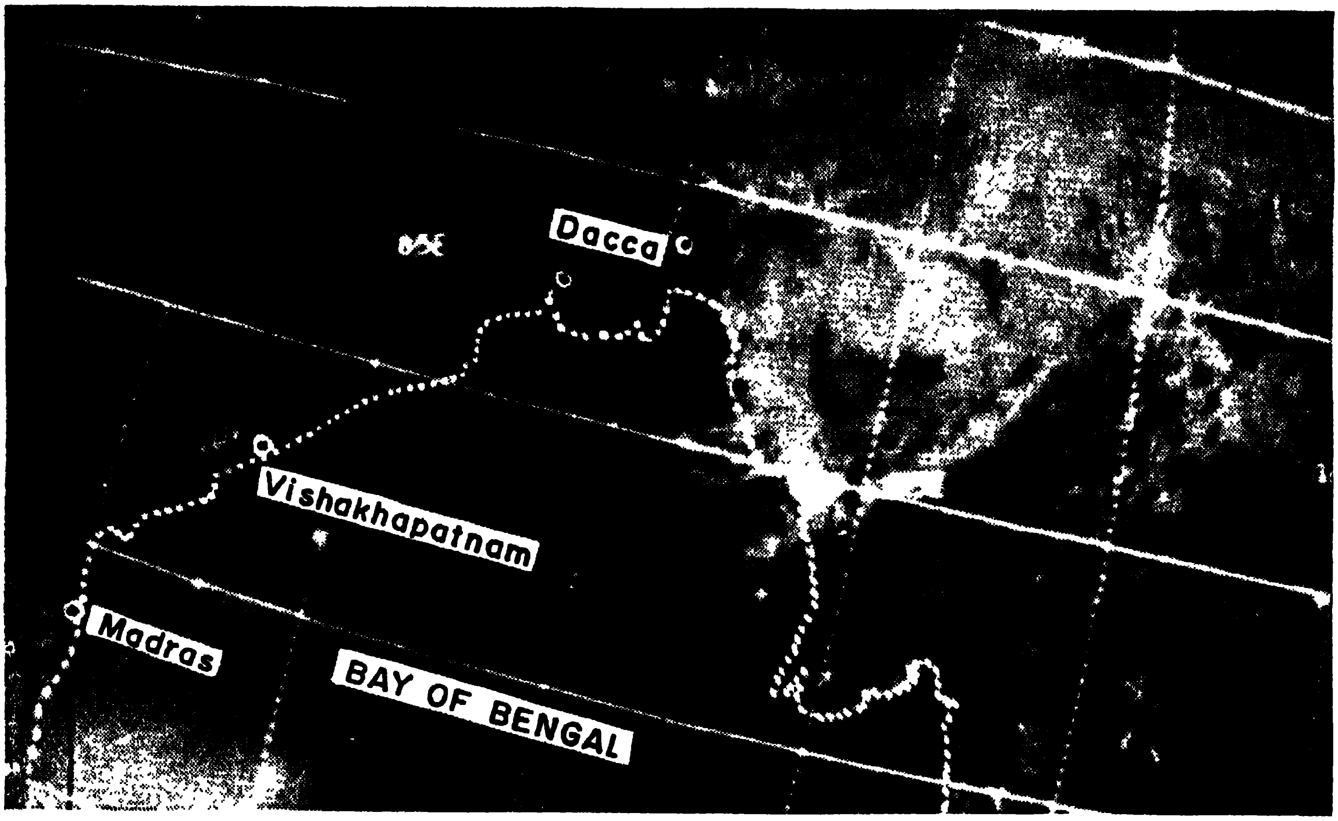
3. (Above) Nov. 10. Orbit No. 3639; time: 15h 27m IST. Here the clouds have formed into thick smaller circular bands and the "eye" has become more prominent. It is seen moving toward north

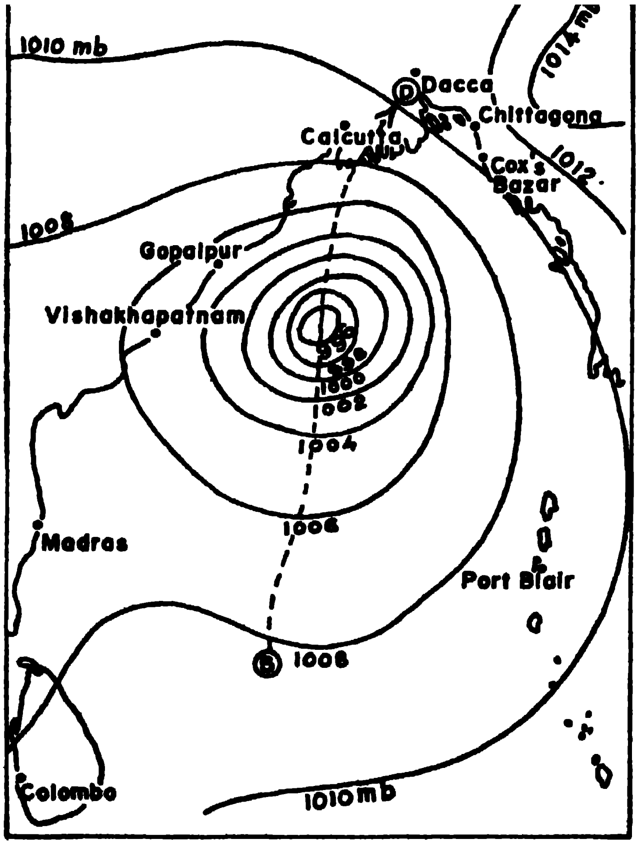
4. (Below, left) Nov. 11. Orbit No. 3651; time: 14h 29m IST. The cyclone has intensified into a huge vortex with a prominent "eye", which is almost 400 km due east of Vishakhapatnam. The clouds here have extended deep over Burma and China

5. (Below) Nov. 12. Orbit No. 3664; time: 15h 24m IST. Fateful day on which the violent cyclone crossed the coast of East Pakistan toward nightfall. Note the clear "eye" on the cloud mass over sea — a black dot below the "X" mark on the picture frame









6. (Above) Nov. 13. Orbit No. 3676; time: 14h 26m IST. The cyclonic storm has blown over the land area virtually decreasing its fury. The cyclone is dead but remains as a huge cloud mass over Assam, Burma and China

7. (Left) Map of the isobaric pattern on the evening of 11 November 1970 at 17h 30m IST, showing the centre of the cyclonic storm, its birthplace (B) and death (D)

The calamitous killer cyclone, which wrought unprecedented havoc in East Pakistan, will be remembered for a long time to come as one of the greatest natural disasters in historic times. Crossing the coast between West Bengal and East Pakistan on the night of 12 November 1970 (Full Moon day), the cyclone also generated a huge storm surge (also called a storm wave or tidal wave), 6 to 9 metres high, submerging the offshore islands at the mouth of the Ganga and Brahmaputra. Over 2,00,000 people were drowned according to official estimates. Unofficial sources placed the death toll at 6,00,000. Some 14 islands were completely eroded and disappeared from the map of the region.

M. P. Rao

[M. P. Rao is Assistant Meteorologist at the Meteorological Office in Poona.]

BLURS & BRIGHT

An ecological 'Che'

DEBATERS debate and ecologists hop-step from one conference to another with taut, frayed nerves. But nobody seemed to have come across the idea that paying people in their own coin does sometimes get results. Except one man. His identity is still unknown, although he signs his name as " The Fox ", possibly after the heavily polluted Fox river in Chicago. Students call him an ecological Che Guevara. According to *New Scientist*, he started by blocking the effluent pipe of an Illinois factory and another factory had its chimney mysteriously capped. In fact, in the Chicago industrial area, " The Fox " has already become a scare. Industrialists whose factories exude offensive smell are liable to find dead skunks on their door steps.

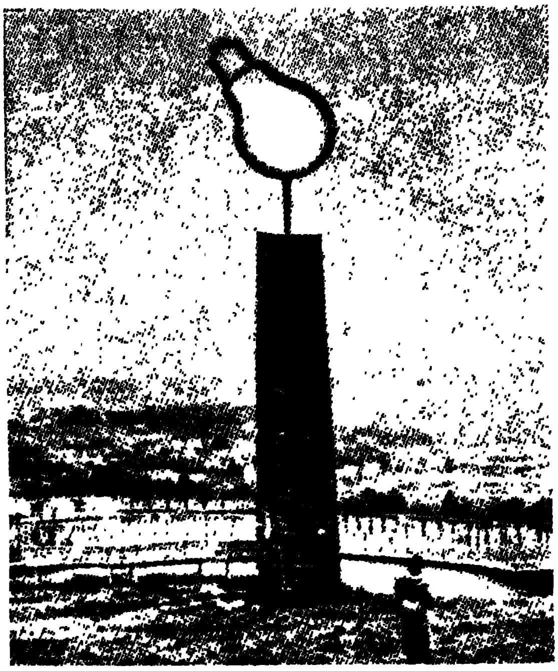
His latest act of retribution was rather dramatic. He walked into the plush Chicago office of a vice-president of US Steel and emptied a bottle of industrial muck over the white carpet. Then he handed over a coffin-shaped small box to the dumb-founded V.P. and walked off. When the police opened the box, they found a dead perch, a crayfish and a frog as well as a small bottle of effluent taken from US Steel's waste pipe at Gary, Indiana. " They keep saying that they aren't really polluting our water. If that's true, then it shouldn't hurt his rug." The Fox's comment.

The police are reportedly looking for him. Again reportedly, they are *not* trying very hard.

Viet Nam syndrome

THE biggest syndrome of the Viet Nam war is the funny little war itself which nobody can ever win. The other, recently described by American psychiatrist Chaim Shatan, is the gradual dehumanisation of the participants: more and more Viet Nam war veterans have been feeling a loss of their ability to love and trust — as a result of their involvement in the Indo-China War.

Psychiatrist Shatan, who calls it the " Viet Nam syndrome," says the war veterans feel that the loss may be permanent and that they exhibit other symptoms such as " pervasive guilt feeling over what they have done to the Viet Namese and a sense of alienation from themselves . . . As an outcome of modern counter-insurgency combat training, the Viet Nam war is in all probability the most extreme example of the gradual habituation of a nation's soldiers to torture, then atrocity, later massacre and finally — though not yet — genocide."



Too late, Mr. Edison? Statue of the electric light bulb stands outside Springe, West Germany, in memory of a local inventor, Heinrich Goebel. According to local citizenry, Herr Goebel invented the electric light bulb a full 25 years before Thomas Edison, who is given the credit.

Those noisy female thighs

MINISKIRTS are easy on the eyes but can be hard on the ears. Clothes absorb sound. With fewer clothes, a person reflects more sound waves.

Dr. Vern O. Knudsen of the University of California, Los Angeles, points out that concert halls are designed with the idea that most audiences will be fully dressed. However, as skirts go up and absorption goes down, acoustical calculations may be thrown off.

they throw money away on purpose

STEVE BACON

IT'S lying there temptingly, a new black split-cowhide wallet in the middle of the sidewalk with money and a large piece of paper protruding. You pick it up, glance around to see if you can spot the owner, then look inside. The contents include two crisp one-dollar bills (or may be $5 or $10 more), a check made out to " E.M.H. Company," a receipt for a rented tuxedo, business cards, membership and identification cards made out to Michael Erwin. The last has both Erwin's address and phone number.

The problem is what do you do next? You can, of course, mail the wallet and its contents back to Erwin or give him a call and ask him to pick it up. You could keep the money and drop the wallet in the nearest mailbox (you note that there are three stamps in the billfold), or keep both the wallet and the money and mail the cards and papers back to Erwin. Then again, you could just take the money and toss the rest into the nearest litter bin.

You're free to do any of the things mentioned and Michael Erwin won't care — as a matter of fact, Erwin doesn't exist — but no matter what you do you'll become a statistic in a study financed by the National Science Foundation and entitled " Experi-

Hidden camera snaps pictures of wallet-finders to record finder's characteristics, and would-be claimants among passersby

ments in the Social Psychology of Pro-Social Behaviour." This tongue-twisting title poses a deceptively simple question: Under what conditions will people help one another?

In an attempt to answer this riddle, Professor Harvey A. Hornstein and his associates at Teachers College of Columbia University, New York, USA, have been losing hundreds of money-stuffed wallets and a good many other things as well. As a matter of fact, they've got the techniques of 'losing things for other people to find' down to an amusing, yet insight-provoking, science.

If the experimental techniques are amusing, the results are of serious import, however. Much of the stimulus for the experiments came from the well-known case of Kitty Genovese, the young New York City woman who was murdered in 1964 before some 38 witnesses, peering from darkened windows, who "didn't want to get involved". A number of research projects on "helping behaviour" have followed in the wake of that shocking episode, Prof. Hornstein's among them. (Another detailed study, "Bystander Apathy," was made by Bibb Latane and John M. Darley. See SCIENCE TODAY, January and February 1970.)

Why, for example, will a group of people observe an unprovoked assault on someone else and do nothing to stop it, whereas a single witness to the crime may attempt to aid the victim? Why is it that a motorist with engine trouble can get help from a passing car on a lonely country road but not on a busy traffic artery? Why do some people return lost or stolen property but not others? How is the prope social behaviour defined in unexpected situation and to what extent do other people serve as model for that behaviour?

In trying to tie down some of these imponderables particularly the one about models, Hornstein an his colleagues provided a built-in model with wallet after a pilot study showed that they would be re turned about 40 to 50 per cent of the time "as is" Wrapped around the shiny new billfolds are type written letters which lead the finder to believe th wallet has been lost not once, but twice. The lette describes the first finder's feelings about returnin

In most " find " events, the camera reveals, finder examines wallet, reads note; passing pedestrians are curious, but keep going

the wallet. Then this well-intentioned person loses the wallet himself along with his letter.

In reading the letter, the real finder now has to decide whether to follow the first finder's behaviour in returning the wallet or whether to simply keep it for himself.

" Dear Mr. Erwin," says a neutral version of the letter model, " I found your wallet which I am returning. Everything is here just as I found it." No more than that; simply the wallet and the short letter. A positive version of the letter from this previous finder goes on to discuss his feelings: " I must say that it has been a pleasure to be able to help somebody in the small things that make life nicer. It's really been no problem at all and I'm glad to help."

A negative letter used with different wallets adds a more petulant tone in the second paragraph: " I must say that taking responsibility for the wallet and having to return it has been a great inconvenience. I was quite annoyed at having to bother with the whole problem of returning it. I hope you appreciate the efforts I have gone through."

Do people read these letters and accept them as models for their own behaviour? The answer is an emphatic " yes ", for 60 per cent of the " neutral " wallets are returned, 70 per cent of the " positive ", and only 10 per cent of the " negative ".

Social psychology

Realising that they had a valuable research tool after the first wallet experiments were conducted several years ago, Hornstein and graduate students Elisha Fisch, Madeline Hellman, Michael Holmes and Kenneth Kressel set out to refine their techniques and to pose ever more sophisticated questions in social psychology. People finding the wallets seemed to accept a letter as a model for behaviour as long as it was written by someone like themselves, but would they do so if the letter were written by a foreigner? Would perception of race — perhaps the inclusion of a photo of a light-skinned or dark-skinned Michael Erwin — make any difference?

What about models who make a point of acting against their own experience or against social pressure

to return the wallets? One letter that really brings them back (60 per cent) has the previous finder standing up against all social pressure in order to do the right thing. " Dear Mr. Erwin," it begins as do all the letters, " I found your wallet which I am returning. Everything is here just as I found it. When I found it everyone who was around (including my best friends) said I should keep it and I was stupid if I returned it. I disagreed with them so here it is." Curiously, a similar letter in which the model finder states that everyone had urged him to return the wallet brought only a small, 20 per cent return rate from real finders.

By way of explanation, acting contrary to social pressure can " often be heroic ", says Harvey Hornstein. " It is the type of thing which is approved by society but not necessarily conformed to on all occasions. If our model is acting contrary to social pressure yet in an approved way, his behaviour becomes more compelling."

But if the experiments to date say something about human nature and helping behaviour, perhaps the techniques the researchers have evolved for losing things and then describing the people who pick them up reveal almost as much about how we think and act. In addition to a " dropper," there is a team of two observers to rate wallet finders as to age, sex, race, apparent socio-economic status and other characteristics.

Dropping techniques

In order to drop wallets on busy New York City streets a special trap door attache case was designed with a release mechanism in the handle. Supposedly the droppers, sort of pickpockets in reverse, would then simply stroll along and release a wallet when the moment seemed just right.

Although dropping techniques vary somewhat, the principal methods include holding the wallet next to a newspaper or inside it and then releasing it when the sidewalk crowd is just right. A variation has the dropper bend down to tie his shoe, putting the wallet and newspaper down on the pavement. When he stands up and walks away, the wallet remains.

Although passersby seldom scramble for the wallets, people will, on occasion, falsely claim to be the owner when others spot them first. Some simply take the money and discard the rest. On one memorable occasion, the team was working outside a large storefront office only to be spotted by the clerks inside. " They wanted to know what kind of racket we were in with all the wallets," says Hornstein. " They didn't really want to stop us — they were just curious."

Another incident occurred at New York's Grand Central Terminal. Shortly after the team had dropped wallets in the vicinity, " Michael Erwin " got a telephone call on the special phone set aside for answering calls from persons finding wallets. " Mr. Erwin," grated a clerk's voice at the terminal, " just what are you trying to pull? " Perplexing the man was the fact that two exactly identical wallets, complete with money, papers, cards and tuxedo receipts, had been turned in at lost-and-found.

Positioning observers near dropping sites proves to be surprisingly easy. Wearing very conventional clothing — a suit or simply pants and sports shirt — the observers blend into this group of idlers, sitting on park benches, reading newspapers or books or casually conversing with each other. Inside the observers' reading material, however, one discovers the printed forms used to rate finders as to their distinguishing characteristics.

Other results

Although it could be argued that the experiments perpetrate a small hoax on the public, it should be pointed out that no one is ever " taken " for anything (as a matter of fact, the experimenters lose hundreds of dollars and almost as many wallets), and those returning wallets receive a polite note of thanks. All finders are contributing, albeit in ignorance, to a growing knowledge of human behaviour. Other results reported to date include the following:

● When possible models for social behaviour are radically different (i.e. foreigners), they are not accepted as models by people finding the wallets. Says the letter model, " I am visiting your country finding your ways not familiar and strange. But I find your wallet which I here return. Everything is here just as I find it." Refusing to accept the foreigner as a model, real finders return approximately 30 per cent of the wallets whether the letter is neutral, negative or positive.

● Letter models who state they are returning the wallet despite the fact that no one has ever returned their lost wallets stimulate a high percentage of returns by real finders, as do those models who state they are bucking social pressure to do the right thing. Curiously, models who state that they are returning the wallet because of social pressure or because their own wallets have been returned do not inspire a high degree of imitation (only 20 per cent) among real finders.

● What role does personal gain play in helping or not helping? To test this a series of experiments was conducted to find out whether wallets containing $11 would provide an incentive for finders to keep the money (and the wallet), or whether they would feel more obliged to return it to Michael Erwin. Apparently greed plays the stronger role, for with $11 available for the taking, only 20 per cent of the finders returned the wallets intact.

● Lower socio-economic status led to a lower return rate, but so did membership in non-white minority groups. The latter finding, theorises Hornstein, may reflect the alienation of these citizens from our society.

● Experiments with " lost " objects other than wallets are also being conducted and offer even further insights into why and when people will lend a helping hand. Typical of these other lost packages is one containing a $2 money order addressed to the " Institute for Research on Medicine," a fictitious organisation to which a fictitious donor is contributing. He is attempting to reach what is stated to be an important, sought-after goal: the sending in of ten cash contributions to the charity. An enclosed form indicates that this contribution is either his second or his ninth.

Why does the number of the contribution make a difference? Because people will help others reach their goals if they are already close to attaining them. If the goal is distant, they are much less likely to do so.

Helping with the goal

Only about half of the donations are sent on by their finders when the contribution is the second. If it is the ninth, 80 to 90 per cent of the finders will continue the helping act begun by the fictitious donor.

As Professor Hornstein has observed, we live in a society in which people agree in principle as to what is good and what is bad. The problem is that the right action to make in unexpected circumstances is often ambiguous, obscured by complicating factors. Where it isn't clear what we should do, we look to models, and the presence of helping models increases the likelihood of helping behaviour.

With or without models, can we overcome the limitations on helping behaviour that doomed Kitty Genovese? That is the hope of men of conscience and men of science.

BRAIN TEASERS

That's torn it

"Now that is annoying," said Archana, looking at the soapflake packet in her hand.

"What is annoying?" asked Rajesh, puffing away at his pipe with his eyes still glued to the racing page.

"This coupon offer. Look at what is says." Rajesh read:

BIG TWO-IN-ONE OFFERS

One bath towel with a hand towel to match...... 285 coupons.

OR

One hand towel with one guest towel...... 220 coupons.

OR

One guest towel with one face flannel........ 135 coupons.

OR

One bath towel with one face flannel.

"And it's the last pair that I really need," said Archana.

"Then why not send off for it?"

"Because that part of the packet showing how many coupons it is worth is torn off."

"Maybe there is some other way of working it out from the other figures they give," suggested Rajesh. "Here let me try."

Could you have worked it out?

Milky's way

The dairyman was in a quandary. The demand for milk had been heavy and now, just as he was about to close for the day, two customers arrived — one with a half-gallon can and the other with a quart-pot.

In his store was just enough milk to fill the half-gallon can.

What to do? Tell the quart-potter that he would have to do without milk for his tea? That would be unkind. Share the milk between them? That would mean a dissatisfied half-galloner.

The only thing was to be fair — add enough water to satisfy both customers. There was water to be had in abundance from the tap, but the half-gallon can was full of milk and the quart-pot was empty.

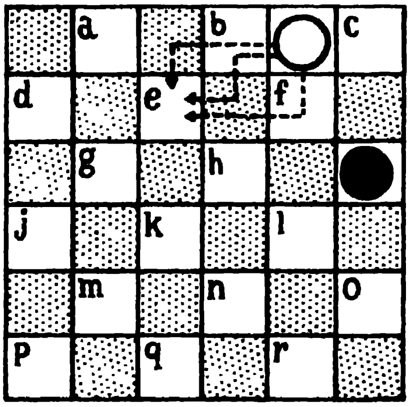
The question was how to add water in such a way that he could give each customer the required quantity of liquid while making sure that the quality of richness was the same in each case — after all, he was an honest dairyman.

The only other measure available was an empty three-pint jug. What was the most expeditious way to carry out his plan?

Counter march

The black and white counters on this 6 × 6 square meet regularly for counter-consultation on one or other of the board's lettered squares.

To avoid scenic monotony, they always take a route which leads them through black and white squares alternately and, because of laziness, invariably take the shortest possible route available from their home squares (on which they are shown).



Often, there is more than one equally short route. For instance, the diagram shows three equally short routes by which white can reach square e, a square which offers black a choice of four equally short routes (one more than white).

Which lettered square offers white just one equally-short route more than it offers black?

Xeno

(Solutions next month)

[Solutions to last month's Brain Teasers on page 55]

Aerial view of the experimental project in Puerto Penasco, Mexico

DESERT FARMING

Carl N. Hodges

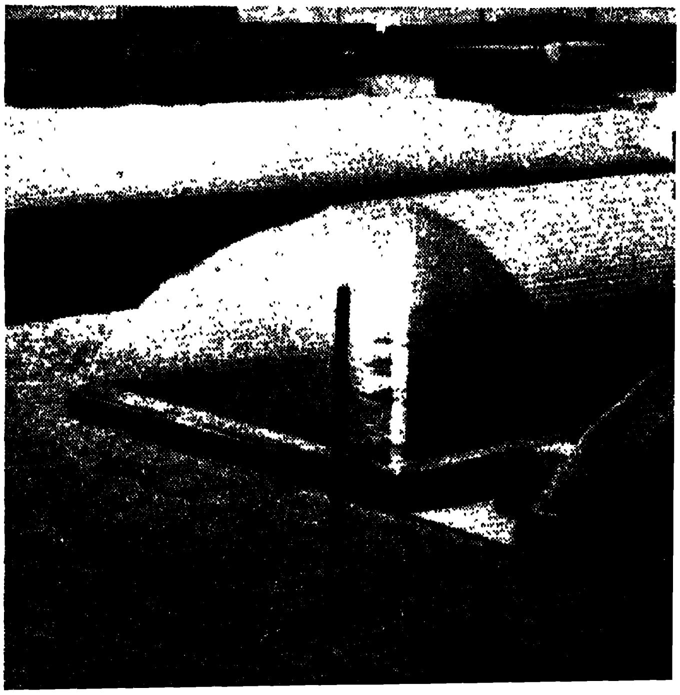
MAN can scarcely afford to overlook his enormous land bank — the deserts. These great dry lands offer much more than just empty spaces; they can be tilled, they can even be desirable places to live in.

Most arid regions which have been irrigated with imported water (from a nearby river or ground water) are already densely populated — often as densely as some regions with ample rainfall.

There are 32,000 kilometres of desert coastline in the world that are, by and large, uninhabited. And if we consider the adjacent areas that are 300 metres or less above sea level, we find more than 680 million hectares (6.7 million square km) of land.

To irrigate this enormous area, to make it fertile, one would require billions of gallons of water. Where would this water come from? One possible source can be the sea. Desaltation technology has already advanced to a practicable stage. Yet, the cost of desaltation is still prohibitive. In such a situation, one exciting alternative will be to change the agricultural technique so that one can use only small quantities of expensive desalted water and yet coax the earth into fertility. In fact such an integrated system providing power, food and water on desert coasts has already been devised by the Environmental Research Laboratory of the University of Arizona's Institute of Atmospheric Physics. The project is sponsored by the Rockefeller Foundation and one facility is already in operation on the Gulf of California at Puerto Penasco, Mexico, and a largescale installation has been started in the Arabian sheikhdom of Abu Dhabi.

The source of power is normally a small engine generator set which is typically a diesel engine. The waste heat usually available in such power production is harnessed to heat sea-water in the desalting plant. Only 10 per cent of the sea-water heated is converted to fresh water. The remainder is rejected



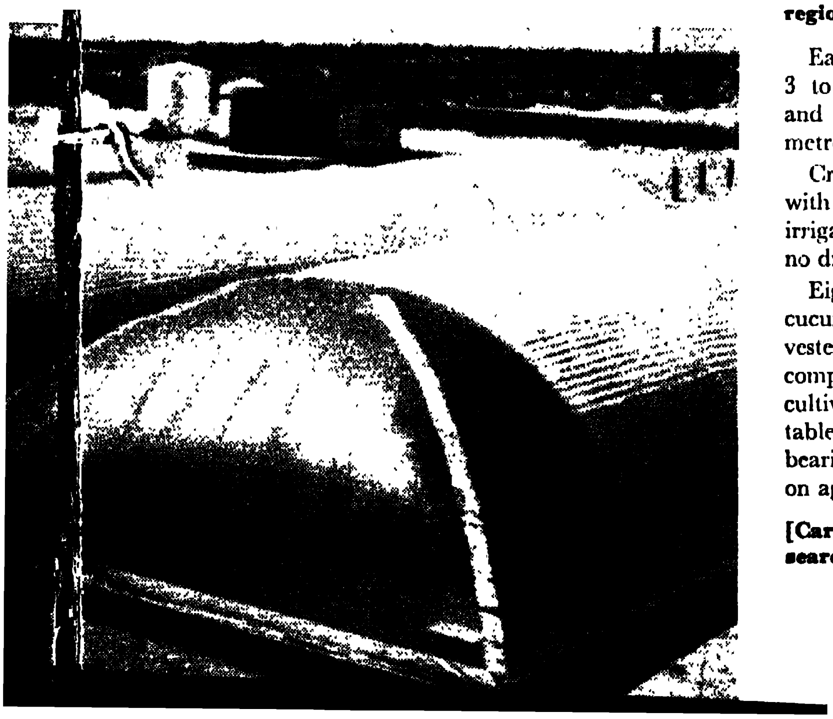
from the bottom of the evaporator at about 10°F (— 12°C) above its inlet temperature; this can then be used to heat the greenhouse.

An agricultural plant in a desert environment needs approximately 100 times its own weight of water during its growing cycle. This is because the stomates of the plant are open and considerable evaporation and transpiration take place on the leaf surface. It appears that most of this transpired water serves no necessary physiological function other than to cool the plant. If the plant can be encapsulated in an environment which does not need fresh water for its cooling mechanism, then the need for fresh water could be reduced significantly.

This idea gave birth to the ' closed environment ' greenhouses. These greenhouses are constructed of air-inflated plastic and as there is very little exchange of air with the outside atmosphere, the environment can be controlled. Inside, the air constantly circulates through a packed column of corrugated asbestos that contains a spray of sea-water. The spray serves two purposes. It either heats or cools the air in the greenhouse, depending on the time of the year and the time of the day. In addition, it continually humidifies the air, letting the plants grow in a high-moisture atmosphere. As a result, transpiration is greatly reduced and plants can grow with very little water.

The four present Puerto Penasco greenhouses of polyethylene film have a predictable life of 12 to 14 months. Their advantage is that they can be tailored and erected by comparatively untrained workers.

The plastic-covered greenhouses used in the project



Tomato yields are twice those in most fertile regions of the world

Each greenhouse consists of two 30-metre-long, 3 to 6-metre-wide half cylinders connected front and back by concrete tunnels. There are 428 square metres for agriculture in each greenhouse.

Crops are planted directly in beach sand leached with desalted water. Nutrients are added to the irrigation water. There are no weeds—and virtually no diseases.

Eighteen different kinds of vegetables — tomatoes, cucumbers, melons, lettuce, etc — have been harvested. Their quality is excellent and the yields comparatively favourable. The present trend is to cultivate high-quality, relatively high-value vegetables to offset the costs. But work is being done, bearing the possible economic limitations in mind, on agronomic crops like rice.

[Carl N. Hodges is with the Environmental Research Laboratory, University of Arizona.]

QUIZ

TEST YOUR KNOWLEDGE OF SPIDERS

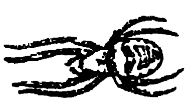
JOHN AND MOLLY DAUGHERTY

OVER 30,000 species of spiders have been named or classified, but probably over 1,00,000 species exist. Spiders belong to the phylum Arthropoda and the class *Arachnida*. Insects, which are different, belong to the class *Insecta*. Spiders have only 2 body parts (insects have 3), 4 pairs of legs and no antennae or wings. The 2 parts of the spider are the cephalothorax and the abdomen. What do you know about spiders?

1. Web spiders produce several kinds of silk from 4 to 7 glands in the abdomen. As the liquid silk issues from the hundreds of silk-extruding tubes of each spinneret, it hardens when exposed to air. The spider pulls out the silk strands. One type of silk is sticky to entrap the prey. Another type is dry for web framing or for drag lines for the spiders' use. Spiders produce other types for special use, for example, silk for egg sacs. The *Nephila* spider produces the strongest known natural fibre.

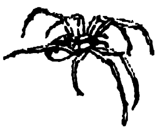
Orb weavers generally spin a sticky thread. Which one of these spiders weaves an orb web with a dry hackled thread?

1a



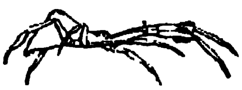
GARDEN SPIDER Araneus diadematus

1b



HAMMOCK SPIDER
Linyphiinae pityohyphantes

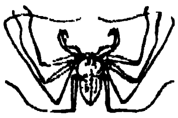
1c



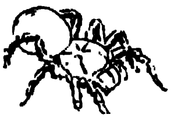
CHIBELLATE SPIDER
Uloboridae glomosus

2. The class *Arachnida* includes not only spiders, but mites, harvestmen and others. Mites are almost microscopic and rate next to spiders in the number of species. Some relatives of true spiders must have had an ancestry in common with each other. These have jaws, 4 pairs of legs and pedipalps which are sometimes like pinchers. Pedipalps, which lie between the jaw and the first legs, are a part of the reproductive system.

Which one of these is only a relative of true spiders?

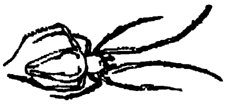


2b



TRAPDOOR SPIDER
Bothriocyrtum californicum

2c

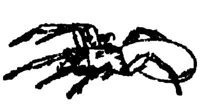


COBWEB WEAVER Spintharus flavidus

3. The size of spiders varies with the species and the kind of environment. Generally the sizes range from a few quarters of a centimetre up to 8·8 cm. The suborder *Orognatha* includes the largest spider, which is found in the tropics along the Amazon in South America.

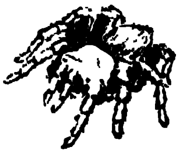
Which is the largest spider of these species?

3a



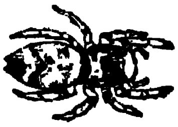
DYSDERIDS Ariadna bicolor

3b



HAIRY MYGALOMORPHS
Aphonopelma chalcodes

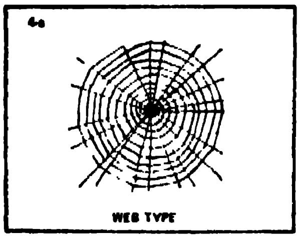
3c

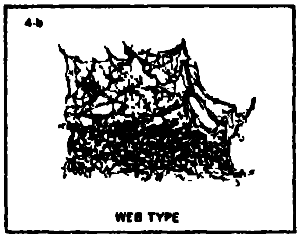


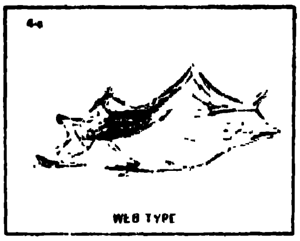
ZEBRA JUMPING SPIDER
Salticus scenicus

4. The webs that spiders weave vary. The spider makes a trap to catch its food. They depend on their ability to produce silk and their capability to manipulate the silk to meet their needs. Hunting spiders, however, usually pounce upon their prey.

Which one of these webs is that of the grass spider?

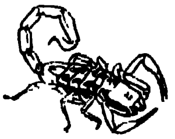


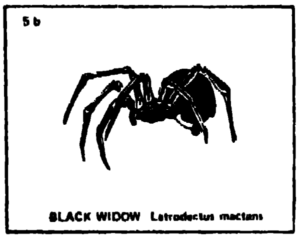


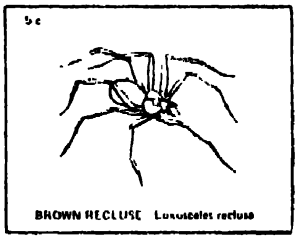


5. Some true spiders and their relatives are poisonous to man. Spiders and scorpions both use venom secreted from special glands to kill small invertebrate animals as food. A few big *arachnids* even kill small vertebrates. In Canada and the US, however, bee and wasp bites fatal to man outnumber those from scorpion stings and spider bites.

Which one among these has been considered the most dangerous?







Answers

1 — c. The Cribellate spider, *Uloboridae glomosus,* weaves an orb web but doesn't look like the orb-weaver species. The cribellate spider has a cribellum which is a plate like a sieve in front of the spinnerets. The calamistra — a row of setae (bristles) on next to the last segment of the fourth leg, pulls silk through the sieve. The dry silk becomes hackled and covered with a wool-like silk to catch the spider's prey.

In **1 — a,** the Garden spider is an example of one of about 2,500 species of orb weavers — nearly all of which weave an orb web.

In **1 — b,** the hammock spider is a sheet web weaver. Its web is found in high grasses or between shrub or tree branches. The spider usually catches its prey from below, drags it through the sheet and wraps it up with silk.

2 — a. Tailless whipscorpion, order of Amblypgi, species *Tarantula marginemaculata.* The whipscorpion's first legs are whiplike. Its head and thorax are wide and attached to the abdomen by a stalk. Its abdomen is segmented.

In **2 — b,** the Trapdoor spider, *Bothriocytrum californicum,* is unique. It uses a spiny rake on its jaws to dig a tubelike burrow. It lines the burrow with silk and covers the opening with silk. The trapdoor spider cuts around the opening cover and leaves part uncut to serve as a hinge.

In **2 — c,** the Cobweb weaver, *Spintharus flavidus,* is a common comb-footed spider. It uses the tiny comb of setae on the end of its fourth leg to throw silk over the prey caught by some sticky threads of web. It bites the prey and sucks it dry.

3 — b. The Hairy mygalomorph, *Aphonopelma chalcodes,* is 6·8 cm long. They generally live on the ground, though some live in trees and others burrow in the ground. They are sometimes called tarantulas, but the name often refers to other species. If you corner this spider, he may rear up on his hind legs or purr.

In **3 — a,** the Dysderids, *Ariadna bicolour,* a true spider is only 1·3 cm. Three pairs of legs point forward and one pair points backward. This spider has 4 lung slits rather than 2 on its abdomen. It traps insects in strands of silk, which radiate from a tublike hiding place.

In **3 — c,** the Zebra Jumping spider; *Salticus scenicus,* is about 1·8 cm long. Many are bright-coloured, some with iridescent scales. It can jump

(Continued on page 54)

THE ANIMAL WORLD

The Mongoose

YOU find them in the old *Panchatantra*, you find them in Kipling's *Jungle Book*, and every time you talk about the mongoose, you talk about snakes. The ancient Indian medical books called the mongoose the *sarpa-vaidya* or snake doctor. The mongoose can kill snakes, that has been proven. But it doesn't, not as a habit. In fact, left to themselves, they would rather keep each other arm's length away.

How then did this reputation as a snake-killer get established? Since their relationship is hardly predatory, it may be safe to presume that sometime in the long distant past, somebody had marvelled at the sight of a mongoose killing a snake and came upon the idea of domesticating it. A playful pet and a protector against snakes !—the mongoose soon took on its elevated status.

In Egypt, like most other animals, the mongoose was first domesticated and then given a godly throne. For long it was thought the diurnal mongoose and the nocturnal shrew mouse were the same animal which increased its size at dawn and shrank again at sunset. An Arabian natural historian described a mouse-like Egyptian animal which, when entwined in the coils of a snake, took a deep breath and puffed up its body, breaking the snake into bits.

Aristotle too had taken note of them. He wrote that mongooses acquired an artificial armour by rolling in water and dirt or mud and drying their coat before waging war with snakes. In India, it is said that it makes use of a herb (mangus wail) to overcome the deadly effects of snake-poison. Myths are galore, but the truth is a rather docile anticlimax: the mongoose is primarily an efficient mouser and snakes are quite rare on its menu.

The mongoose probably originated in Africa from where one single genus, *Herpestes*, spread to South Asia and Spain. Six species are found in India of which the common Indian mongoose (*Herpestus edwardsi*) is a favourite pet with snake-charmers.

They are essentially terrestrial animals, living in burrows which they dig out themselves or in cavities among rocks and tree roots. Their ears are small and constructed in a series of complicated folds, which can be closed to prevent dirt from entering while burrowing. The short legs and joint headshape also help in burrowing, although some just take over the homes vacated by their prey. There is only one arboreal species, *H. sanguineus*, and all species are good swimmers.

They are predatory animals that rush headlong on their prey after ferreting them out of their homes, quite unlike cats which lie in ambush or hunt stealthily. Being short-legged animals, they often stand up on their hind feet while hunting to increase their range of vision.

In the animal world, usually the size of the prey depends on the size and strength of the predators. But the mongoose is so bold and ferocious in nature that it can attack animals several times its size. The gregarious species hunt in groups to overcome their larger victims. The Hawaiian goose is said to be able to hold its own against one mongoose, but when attacked by a group, it gets distracted and loses its young to them. Even sambar deer fall prey to a group of mongooses.

Primarily carnivores, they are omnivorous animals. The diet includes rodents, birds, snails, crabs, eggs, crocodile eggs and vegetable matter like fruits, nuts, roots and young leaves. They usually gobble up the prey, but sometimes remain content with sucking their blood only. Eggs are also sucked after boring a hole at one end. Hard-shelled objects are broken by either striking against the ground or throwing them with considerable force (enough to hurt a man) between their hind legs onto a hard surface.

Though bold and alert in nature, they sometimes develop cold feet. Stink glands or anal glands are among their protective devices. All mongooses have these glands but only two — the crab-eating mongoose, *Herpestus urva*, and the striped-neck mongoose, *Herpestus vitticolis* — are known to use them, discharging a vile-smelling and acrid secretion to deter their enemy. When attacked they roll on their backs using the paws to repulse the foe. Their main enemies are the big cats, dogs and birds of prey. Sometimes, man is also the hunter — mongoose meat is a delicacy in some parts of Africa and China.

Mongooses have often been domesticated to control rodent populations. At first they are efficient but when rodent population decreases, they attack poultry and crops, becoming pests themselves, as has happened in Jamaica where they were imported to control the rodent population in sugarcane plantations. All went well for a time; then the protector developed a taste for sugarcane and became a menace. What is more, they started destroying natural fauna by driving some species almost to the brink of extinction, till they themselves fell prey to ticks (which attack cattle and whose number used to be kept down by the once numerous snakes).

Not much is known about the mongoose's breeding habits in the wild or its means of communication. The young are seen during any part of the year and are cared for by the mother alone. The mother enlarges the burrow whenever she expects a litter, which is small but frequent. Gestation varies from species to species; in the common Indian mongoose, it is 8 or 9 weeks. The mother helps them suckle by keeping them close, underneath at first, and as they grow up she lies on her back to nurse them. A hoarse mew uttered by the mother summons her young when they stray away from the group. Anal glands are also supposed to be useful for identifying within the species. They rub their glands wherever they rest or sit down, and re-mark the spot every time they pass it.

The mongoose goes close to the cobra to induce it to strike, then quickly sidesteps to avoid the fangs. It bristles up to twice its size when excited. This, perhaps, misleads the snake into striking short

Once weaned, the mongoose mother starts teaching the youngsters to hunt and feed and protect themselves.

In the wild they usually keep away from snakes; but whenever they meet, each species reacts differently. Some ignore, some attack and some even flee. Their ability to kill the vicious cobra has greatly fascinated man. In a duel, the mongoose usually emerges a victor but it may also sustain injury and die. That mongooses are immune to snake poison is not true, nor is it a fact that they eat a sort of herb as an antidote to poisoning. By nature some animals have a greater tolerance to certain toxins. For instance, pigs, cats, dogs and hedgehogs have a quite high tolerance against snake venom, and then the cat is more tolerant than the dog. The mongoose is another such animal. Experimentally it was found that eight times the amount of poison required to kill a 2-kg rabbit proved fatal to a mongoose only about half that weight. Non-immunised mongoose serum given to rabbits made them outlive the control animals when they were all injected with the same amount of snake venom.

Thus it is not this partial immunity against venom but its quickness and agility that are its assets when at war with snakes. While attacking, a cobra raises about a third of its body from the ground ready to strike its prey. The mongoose goes close to the reptile inducing it to strike and then quickly sidesteps when the snake strikes. In the course of the battle, it may be lashed at and thrown off by the snake, but it always lands on its feet ready to face the next attack. After the strike the snake remains flat on the ground for a brief moment, during which the mongoose tries to maim its head. After several consecutive strikes the tired cobra loses its speed, and taking advantage of its weariness, the mongoose leaps at the neck, grips it with its teeth, and crushes the skull. Of course, compared to the viper, mamba or rattler, the cobra is at a disadvantage: the immovable fangs of the cobra are placed in front of the upper jaw and it has to bite or chew to inject the venom, and its mouth opens only to 45°; this lessens its chances severely. The viper, on the other hand, has movable fangs and jaws which open to 180°, and can also strike sidewise. In the wild, the mongoose avoids vipers; in the event of a clash, the reptile has greater chances of success. When excited the mongoose bristles up to twice its size which perhaps misleads the snake, making it strike short.

Mongooses often catch and eat small snakes, but they are careful enough to avoid the large ones and the constrictors. They may attack the latter in groups.

Sumati K. Sampemane

QUIZ *(Contd. from page 51)*

many times its own length to catch its prey. The jumping spider has 8 eyes, 2 of which are large, giving it excellent vision to see an insect up to 20 cm away.

4 — c. This is the funnel web of the grass spider of the species *Agelenopsis.* Suspension threads of silk stretch from the ground to nearby blades of grass or to flower stems. Around these threads a well-meshed sheet web is constructed, shaped like a flared tube and forming a funnel at the ground. The spider waits in the funnel until he dashes forth to seize its prey.

In **4 — a,** the orb web is an engineering marvel. The spider has remarkable instinct and adaptability for building its orb pattern under varying conditions and in varying sites.

In **4 — b,** is a sheet web without precise pattern or texture. The spider lays hundreds of dry lines close together, random fashion and in different thicknesses.

5 — b. Black widow, *Latrodectus mactans.* The male widow does not bite, but the bite of the female is poisonous. This spider is found in warm climates. Most of the black widows have an hour-glass marking on their underside. Their bite may not be noticed at first. Later, severe pain in the abdomen as well as pain in muscles and feet occurs. The patient usually recovers after several days. An antivenin is available in most countries where black widows are found.

In **5 — a,** the scorpion, *Sculptured centruroides,* has a poisonous sting which affects the nerves and gives severe pain. In Mexico, species of centruroides have caused deaths.

In **5 — c,** the Brown recluse, *Loxosceles reclusa,* has been known to have a poisonous bite. In most cases, a red zone appears around the bite, and after a crust forms and falls off, the wound becomes deeper and deeper and may take months to heal. Some fatalities have been reported recently.

Score yourself :

4 — 5 right. You're in your orb on this.

2 — 3 right. A few cobwebs in your corner.

0 — 1 right. You were trapped on this.

BOOKS

The Chemistry of Life edited by Joseph Needham, Cambridge University Press, London, 1970.

A NUMBER of renowned English biochemists, most of them from Cambridge, had delivered a course of lectures about 10 years ago on the history of biochemistry. *The Chemistry of Life* is a collection of those lectures with a scholarly introduction by Joseph Needham. The book is basically an attempt to bring under one volume some of the historical accounts of the development of biochemistry covering areas as wide as the discovery of vitamins and the history of neurobiology. In a way the title is a misnomer. Considering the fact that the lectures were delivered during the period 1958 to 1961, and that the book was published as late as this year under the above title, it is unfortunate that there is no mention of the discovery of DNA and of the later events that shook the world of biology. Surely the experiment of Avery, MacLeod and McCarty showing the role of DNA in transforming one cell type to another, or the elucidation of the structure of this substance in 1953 may not be considered easily dispensable in a book on the chemistry of life. The book surely merited a chapter on this topic at least as an appendix. Omissions such as this only lead readers to wrong perspectives. And that is not fair in an account of history.

Coming back to what the book has to say, one is otherwise impressed by the encyclopaedic content of many of the lectures. The one by Mikulas Teich on the foundations of modern biochemistry makes very lucid reading. It presents an account of how the early debate on "organic" chemistry as a different class of chemistry generated events that finally resulted in the recognition of physiological chemistry as a valid discipline today. The excerpts from the correspondence between Liebig and Berzelius reveal very pointedly the line of cleavage that appeared between inorganic and organic chemistry around the middle of the last century. Nearly a third of the book is devoted to an article by Kendal Dixon on the history of neurology. One may not feel the same way as Dr. Dixon on the epistemological limitations of the science of brain ("It is indeed unlikely that the mind of man, in spite of continuous advances in knowledge, is capable of ever comprehending, even to its own limited satisfaction, more than a small fraction of its internal working"). However, his interesting account of the history of the neural sciences dates back to the early sixteenth century and covers periods as late as 1965 in striking contrast to most other parts of the book.

This is a nice review of the early structural work and later biochemical researches on the brain. The article by Malcolm Dixon on the history of enzymes and of biological oxidations is, true to this author's tradition, well written. Besides, there are articles by Robert Hill on photosynthesis, by E. F. Gale on the development of microbiology, by F. G. Young on animal hormones and by Leslie Harris on the discovery of vitamins. The concluding chapter is by Rudolph Peters. He discusses, under the heading of lone pioneers of biochemistry of the last century, the researches of Bence-Jones, Garrod (both father and son) and a few others.

The book deals with history and discusses well the areas that have been chosen to be covered. It contains several valuable photographs, both of men and of their specimens, such as the plate showing Alfred Garrod's uric acid test in urine. Gale's recounting of the story of Leeuwenhoek scraping the burglar's teeth with a knife in the middle of the night makes interesting reading; until the account is completed one does not know that Leeuwenhoek was merely searching for appropriate bacterial specimens for his microscope. Printing mistakes in the book are rare but not absent.

As Hans Krebs has pointed out in his review of this book (*Nature 227*, 1061, 1970) the history of science is very much a part of science and it is nice that history has been told by men who know the subject from the inside. It would be still nicer, however, for future historians to remember that history does not necessarily exclude accounts of living men who made it.

P. K. Maitra

[Dr. Maitra is with the Molecular Biology Group at the Tata Institute of Fundamental Research, Bombay.]

Books received

Direct Current Fundamentals by Orla E. Loper, D. B. Taraporevala Sons & Co. Pvt. Ltd., Bombay. Rs. 9·80

Alternating Current Fundamentals by John R. Duff, D. B. Taraporevala Sons & Co. Pvt. Ltd., Bombay. Rs. 9·50

Concrete Form Construction, D. B. Taraporevala Sons & Co. Pvt. Ltd., Bombay. Rs. 3·10

Ornamental Bulbous Plants by S. L. Jindal, Indian Council of Agricultural Research, New Delhi. Rs. 19·75

Farmers of India edited by C. G. Raghava Kurup, Indian Council of Agricultural Research, New Delhi. Rs. 28·00

QUESTION & ANSWER

The Low Temperature of Space

Why does one talk of the "low temperature of space"? How can empty space have a temperature?

ONE shouldn't and it can't. Temperature is the average heat-content per atom of a quantity of matter, and it is only matter that can have a temperature.

Suppose a body like the Moon existed in space, light-years away from even the nearest star. If the Moon were at 25°C. to begin with, it would lose heat by radiation continually, but it would also gain heat from the radiation of the distant stars. The radiation reaching it from the stars would be so small, however, as not to balance the loss through the Moon's own radiation, and its temperature would begin to drop at once.

As the Moon's temperature dropped, the rate of loss of heat by radiation would decrease steadily until finally, when the temperature was low enough, the radiation loss would be small enough to be balanced by absorption of radiation from the distant stars. The Moon's temperature at that point would be small indeed, only slightly above absolute zero.

It is this low temperature of the Moon, far away from all stars, that is an example of what people think of when they speak of the "low temperature of space."

Actually the Moon isn't far from all stars. It is quite close, less than 200,000,000 km from one of them, the Sun. If the Moon were in its present position, but faced one side of the Sun at all times, that side would absorb solar heat until the temperature at the centre of the sunward face was well above the boiling point of water. Only at that high temperature would its own radiation-loss balance the large solar influx.

The Sun's heat would travel only exceedingly slowly through the insulating substance of the Moon itself, and the surface facing away from the Sun would get little heat, and radiate what little it got out into space. The night-side would, therefore, be at the "low temperature of space."

But the Moon rotates with respect to the Sun so that every part of its surface gets only two weeks worth of sunlight at a time. Under this limited period of radiation, the surface temperature of the Moon reaches only as high as the boiling point of water in particular places. During the long night, the temperature remains no less than 120 degrees above absolute zero (cold enough by our standards) at any time because before it can drop lower, the Sun rises again.

The Earth's is an entirely different case, because it has an atmosphere and oceans. The ocean soaks up heat more efficiently than bare rock does and gives it up more slowly. It acts as a heat cushion, its temperature rising not as high under the Sun nor falling as low in the Sun's absence than land would do. Besides, the Earth rotates so rapidly that most spots on its surface experience day or night only for a few hours at a time. In addition, Earth's atmospheric winds carry heat from the day-side to the night-side and from the tropics to the poles

It follows then that the Earth experiences a range of temperatures far smaller than the Moon does even though both bodies are the same distance away from the Sun.

What would happen to a man exposed to the sub-Antarctic temperatures found on the night-side of the Moon? Not as much as you might think. Even though dressed in insulated clothing on Earth, we lose body heat rather quickly to the particulate atmosphere and its winds — which carry body heat away swiftly. The situation on the Moon is quite different. There, in thermal space suit and boots, a man would experience little heat loss by conduction to the surface, or by convection to empty space with zero wind. He'd be in a thermos bottle sitting in a vacuum, radiating only small amounts of infrared. Cooling would be a slow process. His own body would, of course, be producing heat all the time, and he'd be more apt to feel too warm than too cold.

Isaac Asimov

Solutions to last month's Brain Teasers

The big move-round: The job can be done in six moves — bath to bedroom, table to living room, unit to kitchen, bed to hall, bath to bathroom and bed to bedroom.

The age-old question: Malathi was 20, Lakshmi was 23 and Ambika was 21. These are the only three ages which make each girl tell exactly two truthful facts.

The page problem: The pamphlet must originally have contained 14 pages (which had they been all present, would have totalled 105), but the leaf bearing pages Nos. 7 and 8 was missing.

HOW DOES IT WORK?

Electric Clocks

THE motors used in electric clocks are of the synchronous type. Some of these motors are self-starting, while the others must be turned by hand to give them the starting torque. Synchronous motors possess the characteristic of constant speed and this makes them useful for driving devices which must be absolutely synchronised with the supply frequency. It then follows that an electric clock manufactured to operate on 60 hertz (cycles per second) will not operate accurately when connected to a 50 hertz supply system even though the working voltage remains within the specified limits.

The synchronous motor is an AC motor in which the rotor revolves in step, i.e. synchronised with the rotating magnetic field produced by the stator winding. This action means that a magnetic field of a two-pole motor, when connected to a 50 hertz supply, revolves at the rate of 50 rev per sec, i.e. 50 × 60 = 3,000 rev per minute. If the motor has four poles, then it would revolve at half the speed if the supply frequency were the same.

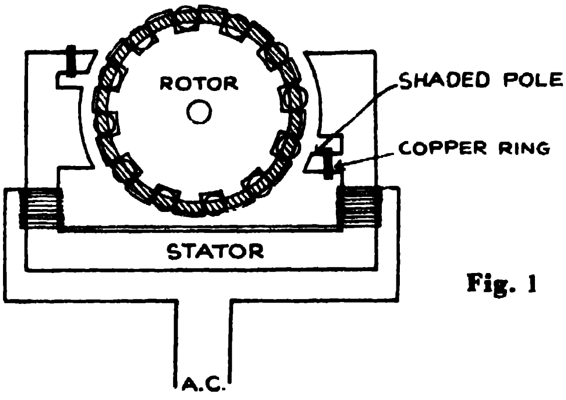


Fig. 1

SHADED POLE SELF STARTING SYNCHRONOUS MOTOR

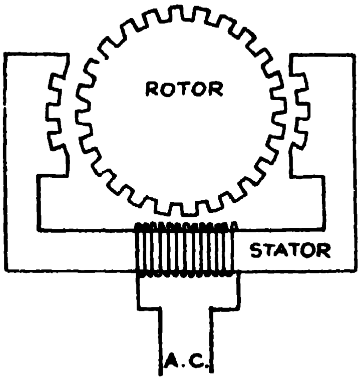


Fig. 2

NON-SELF STARTING SYNCHRONOUS MOTOR

The starting torque for self-starting synchronous motors is given by the shaded poles. The mode of application of the shaded poles to the two-pole motor is shown in Figure 1. A thick copper ring is placed about a pole tip on each of the poles. The effect of the shading ring is to produce a lagging in the magnetic flux, so that there is a sweeping of the flux across the pole face in the direction of the shading ring. This flux cutting the rotor conductor induces currents which, in turn, produce a torque sufficient to start the motor. Usually, the motors have two field poles and therefore should rotate at 3,000 r.p.m. However, the rotor is designed so that it has more than 8 poles. Figure 1 shows the rotor with 12 poles having a synchronous speed of 500 r.p.m.

The non-self-starting motor shown in Figure 2 does not have shaded poles, hence it is not self-starting. When the clock is switched on, a pulsating magnetic field is established which cuts the rotor poles, magnetising the poles on the rotor but producing no torque. However, if the rotor is given a manual start, its poles will be attracted towards the stator poles and will lock in step with the pulsations of the current, thereby keeping the motor running at synchronous speed. The number of poles on the rotor determines the speed. Figure 2 shows the rotor with 24 poles having a 250 r.p.m. speed. There are other types of synchronous motors too, but, in several, they are similar to those described above.

Battery-operated clocks do not have electric motors to give the movement. The electrical circuit of such clocks is shown in Figure 3. These clocks generally operate on a single 1·5 volt torch cell.

When the battery is not connected, the action of the spiral spring tries to turn the bar in the anti-clockwise direction. This causes the electrical contacts (as shown in the figure) to close. When the battery is connected, the current flows through the coil of electromagnet and the electromagnet attracts the armature. This gives a mechanical pulse to the bar connected to the spiral spring assembly and the electrical circuit opens. Due to momentum the bar goes away and returns and once again makes the electrical circuit complete. This again brings the mechanical pulse to the barspring assembly and the process repeats.

The mains-operated clocks using synchronous motors do not require the balance wheel as the revolutions of such clocks are highly constant. But the

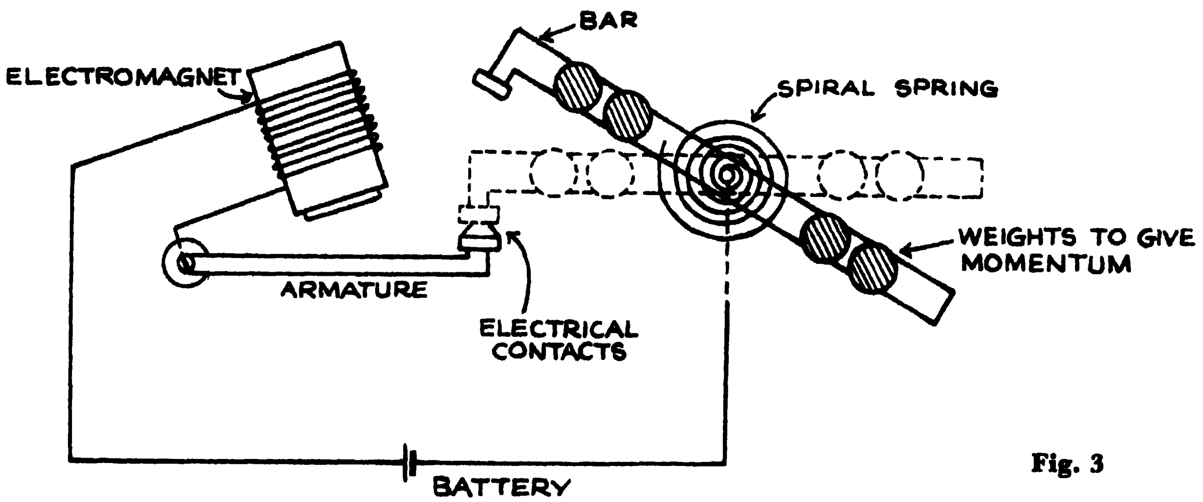


Fig. 3

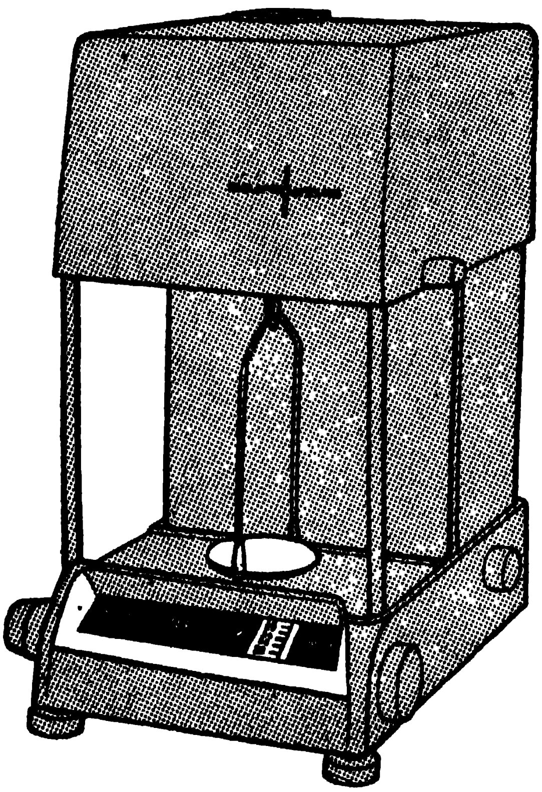
ELECTRICAL CIRCUIT OF BATTERY OPERATED CLOCKS

battery-operated clocks do need balance wheels as the pulses obtained are not so regularly periodic as to be used for timing.

The troubles incurred in synchronous motor clocks are lack of lubrication and worn bearings. Frequently, a thin lubrication oil on the rotor bearings will put the clock in operation, but if the bearings are badly worn the clock may operate only for a while. A watchmaker can replace the worn bearings.

When using battery-operated clocks, it is important that the battery should be removed when the clock stops and it is also advisable to use leak-proof batteries. Otherwise, the battery leakage will corrode the delicate gears and they may get locked in their position.

Hemant V. Borkar


There can be no substitute for accuracy

In research. Or chemical analysis. There is no room for chance, no substitute for accuracy. Success depends on precision.

For all exacting work, you can count on Sarabhai M. Chemicals' 'Guaranteed Reagents'. They provide the utmost precision in high grade production, chemical analysis and research. Specific preparations are available for every requirement. Write to us about your requirement.

GUARANTEED REAGENTS (G.R.)
pro analysi
by
SARABHAI M. CHEMICALS LTD.
Post Box No. 80, Wadi Wadi, Baroda

FOR YOUNG READERS

LANDING ON THE MOON

Apollo Historical Summary

INITIAL planning for a launch vehicle having a payload capability of the Saturn I began in April 1967. In August 1958, studies concluded that a clustered booster of 0·75 million kg thrust was feasible and the research and development effort was begun. Initial results proved that the engine clustering technique, using existing hardware, could furnish large amounts of thrust.

Rocketdyne, a division of North American Rockwell Corp., updated the Thor-Jupiter engine, increased its thrust, thus developing the 1,00,000 kg thrust H-1 engine. Concurrently, from advanced studies, the 0·75 million kg thrust F-1 engine was conceived and subsequently used as the power plant for the even larger boosters. In October 1958, the Army team moved to develop a high-performance booster for advanced space missions. Tentatively called Juno V and finally designated Saturn, the booster was turned over to NASA in later 1959.

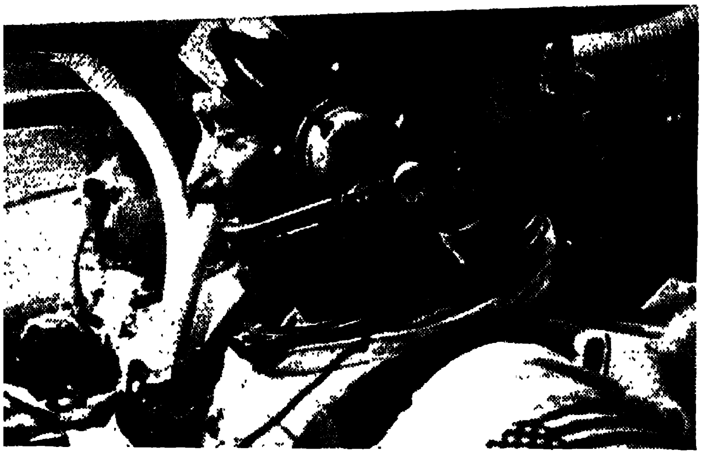
In July 1960, NASA first proposed publicly a post-Mercury programme for manned flight and designated it Project Apollo. The Apollo goals at that time were Earth-orbital and circumlunar flights of a three-man spacecraft. During 1960, Douglas Aircraft Company, Inc. (now McDonnell Douglas) was selected to build the Saturn I second stage (S-IV) and Rocketdyne was chosen to develop the hydrogen-fuelled J-2 engine for future upper stages of the Saturn vehicles.

On 25 May 1961, the late President John F. Kennedy proposed to the US Congress that the United States accelerate its space programme, establishing as a national goal a manned lunar landing and return by the end of the 60s.

With endorsement by the US Congress, the objective of manned lunar exploration created an immediate need for a considerably more powerful booster — later designated the Saturn V. Following another six-month study, NASA announced in January 1962 that the Saturn V, using a cluster of five F-1 engines, would generate 3·5 million kg of thrust, thus providing the lift-off power for the lunar landing programme. After announcing that NASA would undertake the task of developing the Saturn V, contracts were awarded to Boeing Company and North American to build the first two stages of the Saturn V. The second stage has a cluster of five J-2 engines developing a combined thrust of about 4,50,000 kg. The third stage (S-IVB) and instrument unit were already under development for the smaller Saturn by Douglas Aircraft and IBM, respectively.

Later in 1962, NASA announced it was developing the Saturn IB which combined the first stage of the Saturn I and the top stage of the Saturn V for Earth orbital tests of the Apollo spacecraft. In August 1961, MIT was selected to develop the Apollo spacecraft guidance and navigation system. Three and a half months later, NASA selected North American Rockwell Corp. for the Apollo spacecraft command and service module programme.

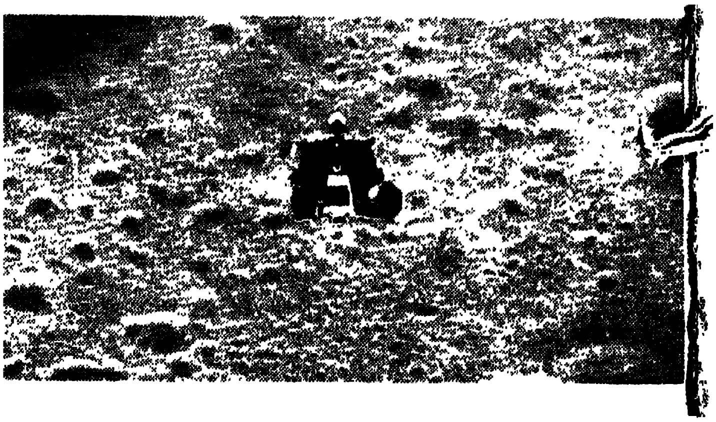
In mid-July 1962, NASA selected the lunar orbital rendezvous mode for the lunar mission. This called for development of a two-man lunar module to be used for landing on the Moon and returning to lunar orbit. Grumman Aircraft Engineering Corp. was selected to design and build the lunar module. One year later, the first Apollo command module was flown at White Sands Missile Range in a launch pad abort test. The first high altitude abort was successfully demonstrated on 13 May 1964. Fifteen days later a Saturn I placed the first Apollo command module into orbit from Cape Kennedy. On 26 February 1966, the first full system Apollo command



pollo 7. Walter Schirra,
onn Eisele and Walt
unningham

pollo 9. LM in Earth orbit — peeling
f the Saturn 3rd stage shell

pollo 10. Moon landing dress rehear
al. LM 15 km from Moon surface



module was launched aboard a Saturn IB, and the module's re-entry heat shield was successfully tested.

The first phase of the Saturn launch vehicle programme had been completed in 1965. All 10 flights of the Saturn I were successful — an unprecedented record in rocket development. The rocket guidance system was developed. The concept of clustered rocket engines was validated and the programme supplied experience in using liquid hydrogen as rocket fuel. Liquid hydrogen provides double the fuel economy of earlier fuels.

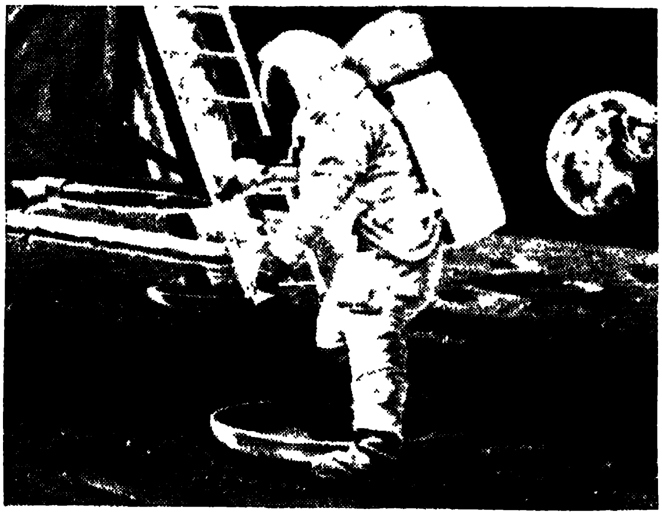
But on 27 January 1967, tragedy struck. A fire erupted inside an Apollo spacecraft during ground testing at Cape Kennedy, resulting in the deaths of astronauts Virgil Grissom, Edward White II and Roger Chaffee. After two and a half months of investigation, involving 1,500 people, the Board of inquiry determined that the most likely cause of the fire was electrical arcing from certain spacecraft wiring. After an extensive investigation, NASA went on to redesign the Apollo system completely.

On 9 November 1967, the first flight test of the Apollo Saturn V space vehicle was successfully accomplished. Designated Apollo 4, the unmanned flight demonstrated performance of the previously unflown first and second Saturn V stage. The Saturn V placed a total weight into orbit of over 1,39,340 kg. The spacecraft's heat shield performed satisfactorily during the 39,680 km per hour plunge into Earth's atmosphere.

During the 22–23 January 1968 Apollo 5 mission, lunar module systems and structural performance met all objectives, including two firings of both the ascent and descent engines. The unmanned Lunar Module I was boosted into Earth orbit by a Saturn

Apollo 8. First close-up view of the Moon. They read the *Genesis* . . .

Apollo 11. Neil Armstrong . . . " a giant leap for mankind "



IB. The lunar module was now ready for manned Earth orbital missions.

The 4 April 1968 flight of Apollo 6 was the second unmanned Saturn V mission to demonstrate launch vehicle and spacecraft systems performance. Two problems were experienced with the rocket systems — vertical oscillations or " POGO " effect in the first stage and rupture of small propellant lines in the upper stages—in an otherwise very successful mission.

The precise re-entry and splashdown on 22 October 1968 of the 11-day Apollo 7 flight goes as a record. Manned by astronauts Walter Schirra, Donn Eisele and Walt Cunningham, the Apollo 7 performed flawlessly for more than 780 hours in space, including 8 firings of the spacecraft's primary propulsion system and the first live TV from a manned space vehicle.

Apollo 8 lifted off precisely on time, 21 December 1968 from the Kennedy Space Center for history's

MANNED SPACE FLIGHT COSTS

MERCURY

Spacecraft	**135,300,000**
Launch Vehicles ..	**82,900,000**
Operations	**49,300,000**
Tracking Operations and Equipment	**71,900,000**
Facilities	**53,200,000**
Total	**$ 392,100,000**

GEMINI

Spacecraft ..	**797,400,000**
Launch Vehicles	**409,800,000**
Support ..	**76,200,000**
Total ..	**$ 1,283,400,000**

APOLLO MANNED LUNAR LANDING COST ESTIMATE

The estimate carries costs of developing and producing 12 Saturn IB and 15 Saturn V launch vehicles, 18 spacecraft command and service modules and 12 lunar modules configured for manned flight, although some of these will be used for other programmes. Also included are costs of all facilities and the manned space flight tracking network. In addition, the cost of all operations in support of manned space flight through fiscal year 1970 is included.

(in billions of dollars)

Apollo spacecraft	**7·795**
Saturn launch vehicles ..	**8·770**
Engine development	**·854**
Operations support	**1·393**
Tracking and data acquisition	**·664**
Facilities	**1·830**
Installation operations ..	**2·412**
Total	**$23·850**

1 dollar = Rs. 7·50

first flight from the Earth to another body in the solar system. Apollo 8 performed flawlessly for 147 hours and over 8,00,000 km of space flight which included 10 revolutions around the Moon, lunar and Earth photography, and live television broadcasts.

Apollo 9 splashed down in the Atlantic Ocean, northeast of Puerto Rico, on 13 March 1969, after a 10-day, 10-million km Earth orbital mission. All major mission objectives were met in the first five days of flight. Apollo 9 was the first all-up manned flight of the Apollo Saturn V space vehicle, first manned flight of the lunar module, first Apollo EVA, and included rendezvous and docking, live television, photographic surveys of Earth, and observation of Pegasus II satellite and Jupiter.

Apollo 10 successfully completed man's second lunar orbital flight, passing within 14 km of the lunar surface in a dress rehearsal for the actual lunar landing mission. Apollo 10 spent nearly 62 hours (31 revolutions) in lunar orbit, sent 19 live colour TV transmissions, and splashed down within 6,300 metres of its primary recovery ship in the Pacific Ocean, 8 days and 3 hours after launching.

Top: Apollo 12. Rendezvous with Surveyor. Above: Apollo 14 crew . . . one veteran

Apollo 11 attained the goal of landing men on the Moon and returning them safely to the Earth within the 1960s. It was launched precisely on time from Kennedy Space Centre on 16 July 1969 by a Saturn V. The LM touched down on the Moon's Sea of Tranquillity on 20 July, and Commander Neil Armstrong stepped onto the lunar surface that evening followed by LM pilot Edwin E. Aldrin, Jr. Their activities were viewed live around the world by the largest television audience in history. The returning spacecraft splashed down in the Pacific, southwest of Hawaii on 24 July after a flight of 8 days, 3 hours and 19 minutes. Scientific instruments were left on the Moon and samples of the Moon's soil and rocks were brought back, along with still and motion pictures.

Exactly four months after the Apollo 11 landing, Apollo 12 repeated this achievement, landing at the Ocean of Storms within sight of the Surveyor III spacecraft that had landed three years earlier. Launched on 14 November, the Apollo 12 mission demonstrated the point landing capability, and placed the first Apollo Lunar Surface Experiments package on the surface for continued science reporting.

Apollo 13 was launched on 11 April 1970 to land on the Frau Mauro upland area of the Moon where the crew would retrieve surface samples and set up geophysical instruments during two EVA periods. A rupture of the service module oxygen tank on 13 April caused a power failure of the command and service electrical system which prevented the lunar landing. The crew used the lunar module as the command post and living quarters for the remainder of the flight. The lunar module descent engine provided propulsion to make corrections in the flight path which sent the spacecraft around the Moon on a free-return trajectory for re-entry and splashdown in the Pacific Ocean 142 hours, 54 minutes and 41 seconds after lift-off.

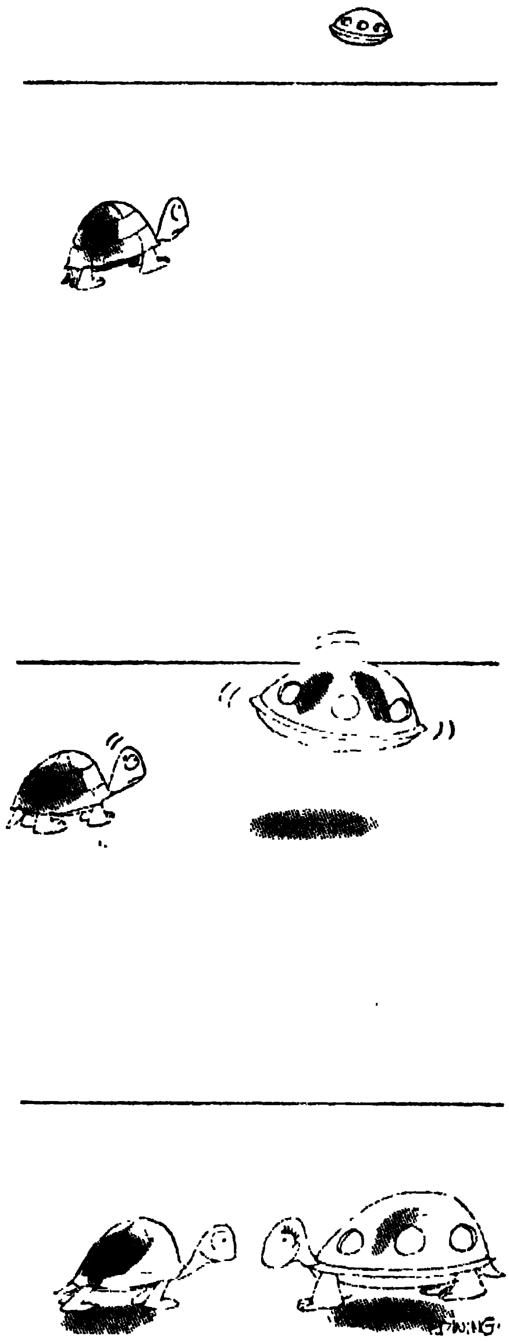
The Apollo 13 Review Board announced on 30 June 1970 that a short circuit ignited the electrical insulation in the spacecraft oxygen tank No. 2, causing failure of the tank.

The spacecraft has been modified to eliminate potential combustion hazards in high-pressure oxygen of the type revealed by the accident. Apollo 14 left for Frau Mauro area of the Moon on 31 January 1971. It returned to Earth on 10 February.

APOLLO MISSION COSTS

	($ in million)
Apollo 7	
Command & Service Module	55
Saturn IB Launch Vehicle	45
Operations	45
	145
Apollo 8	
Command & Service Module	55
Saturn V Launch Vehicle	185
Operations	70
	310
Apollo 9	
Command & Service Module	55
Lunar Module	40
Saturn V	185
Operations	60
	340
Apollo 10	
Command & Service Module	55
Lunar Module	40
Saturn V	185
Operations	70
	350
Apollo 11	
Command & Service Module	55
Lunar Module	40
Saturn V	185
EASEP (lunar surface instruments)	5
Operations	70
	355
Apollo 12 & 13 (per mission)	
Command & Service Module	55
Lunar Module	40
Saturn V	185
ALSEP (lunar surface instruments)	25
Operations	70
	375
Apollo 14 & 15 (per mission)	
Command & Service Module	55
LM	40
Saturn V	185
ALSEP (same as other)	25
Operations	95
	400

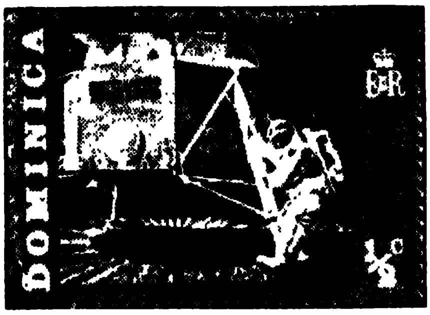
1 dollar = Rs. 7·50



SCIENCE ON STAMPS

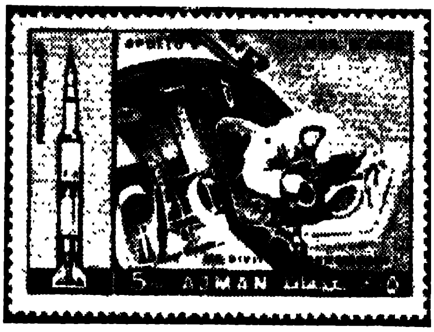
Rupin Patel

JOURNEY TO THE MOON—IV



½c Dominican stamp (above). Multicoloured. Part of a miniature sheet depicting Moon landing.

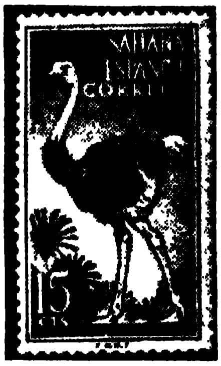
6L Maldivian stamp (below). Multicoloured. From a set of 4 stamps issued in 1969 to commemorate the first Moon landing.

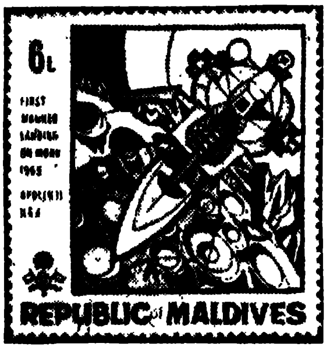


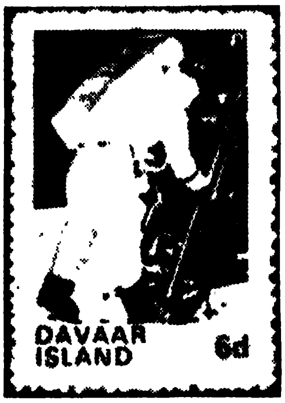
Ajman stamp (above, right). (Ajman is a trucial State in the Arabian Gulf.)

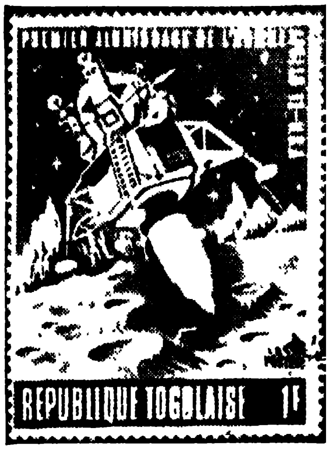
6d Davaar Islands stamp (below). (Davaar Islands lie north of Ireland and south-west of Scotland.)

1f Togolaise stamp (below). Multicoloured. From a set of 4 stamps issued on 21 July 1969.









OSTRICH: *Struthio camelus* is the largest living bird. It is a flightless bird very similar to the emu but with only two toes. The male ostrich is up to 2.5 m tall and weighs up to 130 kg. It has no breastbone. Its bulky body is supported on two long legs which enable it to run at a speed of about 64 kmph. It lives in the sandy plains and open country of Africa, especially East Africa.

Its social instinct makes it travel in groups of four to five. In each group, there is one male and the rest are females. It usually mixes with herds of zebra or antelope.

Its long neck enables it to locate distant objects. It also has very keen eyesight and can trace slight movements over substantial distances.

It normally squats on the ground with its long neck stretched out, peering intently at some far off object. When seen from a distance, only its bulky body is visible giving the impression that its head is buried in the ground.

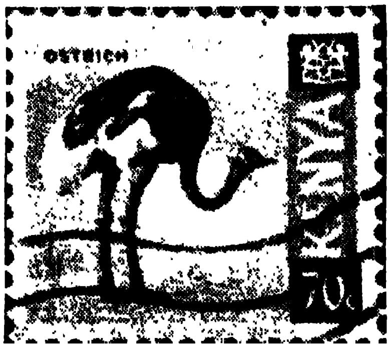
It reproduces by eggs. The hen lays about 15 eggs at a time, each weighing about 1.4 kg.

GUGLIELMO MARCONI: Marconi's studies began the development of shortwave wireless communication and long distance radio communication.

The Italian English inventor was born on 24 April 1874 in Italy. He was regarded as one of the giants of physical sciences at the turn of the 20th century."

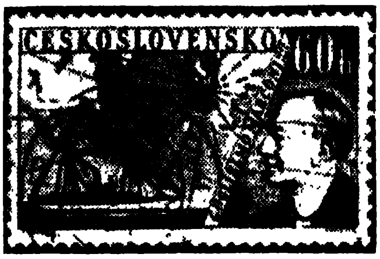
Educated in electrical engineering at the University of Bologna, by 1890, he had advanced and experimented with the theory that electrical current passed straight through any kind of matter. However, his ideas were poorly received in Italy and so he went to England, where he became the first man to develop a method of sending electrical impulses through the atmosphere in a programmed manner.

In June 1896, he took out the first patent granted for wireless telegraphy based on the use of electric current. In 1899, he transmitted intelligible messages by his method from France to England — covering a distance of 20 kms. The following year, he went to the United States, where he installed his equipment between New York and Washington DC to convey the results of the Presidential election. By 1910, he had advanced enough to cover distances of 3,750 km from Argentina to Ireland.



15c Spanish Sahara stamp (above, left). Bistre colour. Issued in 1957.

70c Kenyan stamp (left). Part of a definitive series. Issued in 1966.



60h stamp in blue and black colour, issued by Czechoslovakia on 7 December 1959 as one in a set of 6 stamps depicting radio inventors.

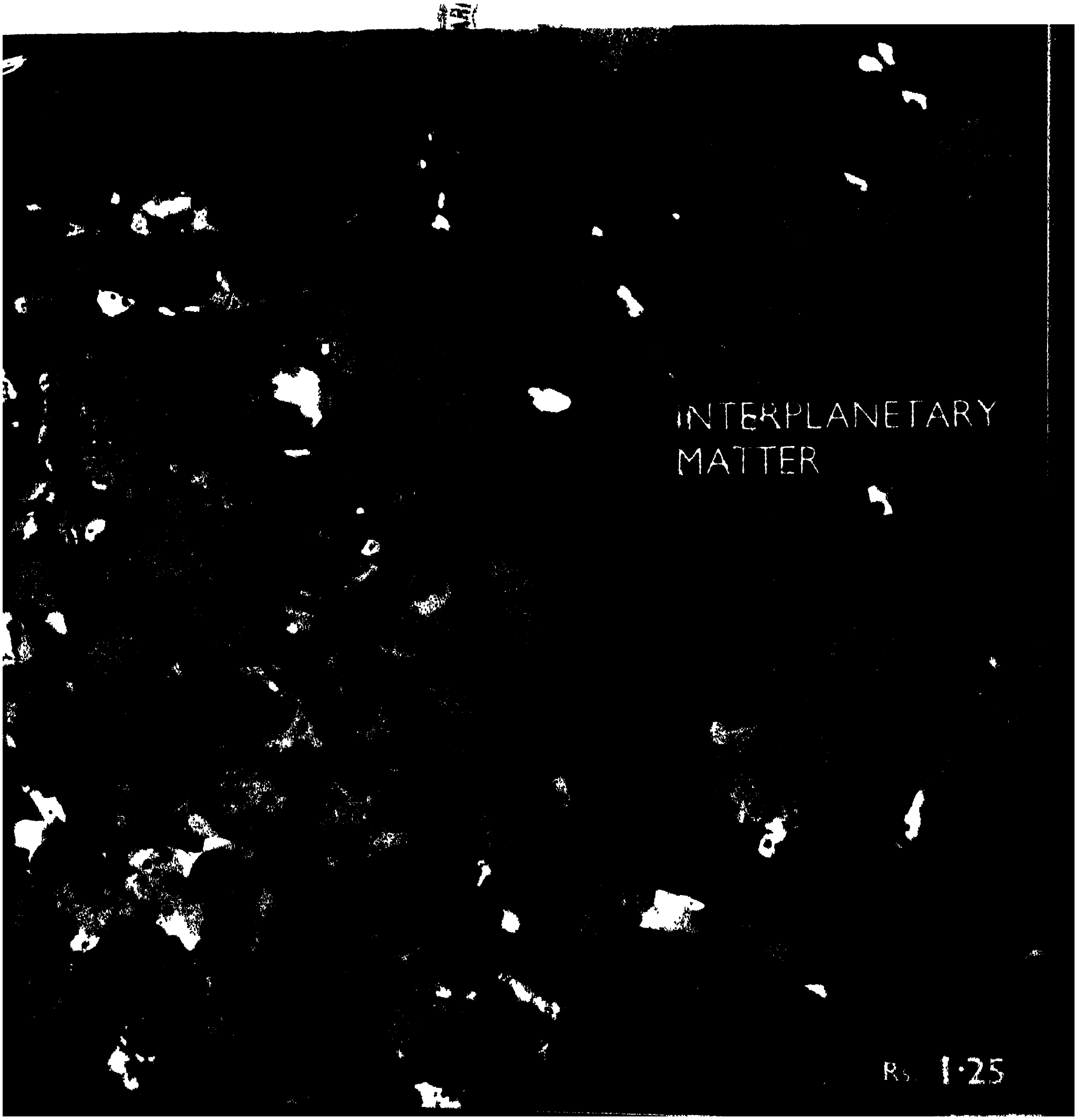
A TIMES OF INDIA PUBLICATION

MARCH 197

SCIENCE TODAY

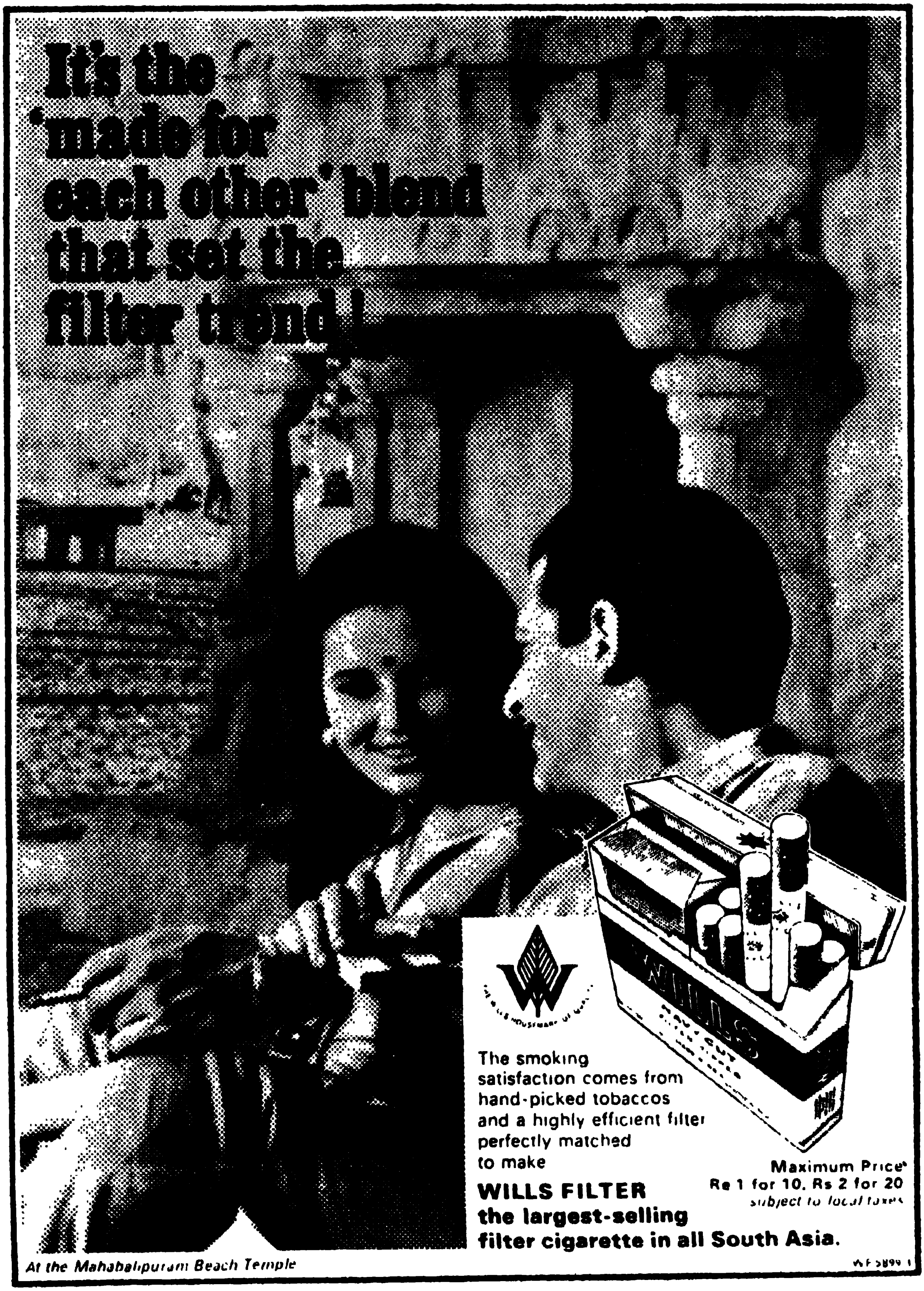
FOR EVERYMA

JAIKRISHNA



INTERPLANETARY MATTER

Rs 1·25


It's the 'made for each other' blend that set the filter trend!

The smoking satisfaction comes from hand-picked tobaccos and a highly efficient filter perfectly matched to make

WILLS FILTER
the largest-selling filter cigarette in all South Asia.

Maximum Price*
Re 1 for 10. Rs 2 for 20
subject to local taxes

At the Mahabalipuram Beach Temple

WF 5899 1

Vol. 5 No. 9 March 1971

SCIENCE TODAY

ARTICLES

INTERPLANETARY MATTER by V. S. Venkatavaradan 15

How did the solar system begin? Men have gone to the Moon to find the answer. But the real clue, many scientists believe, may lie in the smaller meteorites, comets and asteroids

BLOOD GROUPS by H. M. Bhatia 22

There are no blue bloods, there are no 'bad' bloods, only the red that all living things share. But the common factor is not that common, really! From drop to drop, the difference can be counted — in group, in genetic makeup, in the susceptibility to diseases

ADDICTIVE DRUGS by Ajoy Gupta 31

Amphetamines, heroin, LSD, alcohol—ambrosials that open the doors of delight. All are addictives, many are killers. And it was only recently that their pharmacology has been understood

SEX, DRUGS AND ETHICS by Thaddeus Mann 38

Researchers on the human sex have to watch every single step, lest they step on the toes of ethics. Not so for the pleasure-seekers for whom drugs can bring delight and death

HOW TO SUCCEED IN A NEW TECHNOLOGY ENTERPRISE by Edward B. Roberts 46

The ideal entrepreneur does not have to be a technical genius. He should be moderately educated, preferably technically, be able to muster sufficient inaugural funds, and remain content to run a participative organisation

FEATURES

About the Authors 5
Letters 6
Awards & Appointments 6
Focus 7
Science Shapes Life 10
Round-up of Research 27
Blurs & Bright Spots 45
Brain Teasers 51
Books 53
The Animal World (The Crow) 54
You Too Can Do It 56
For Young Readers 59
Question & Answer 63
Science on Stamps 64

(Cover painting by Shabbir Diwan)

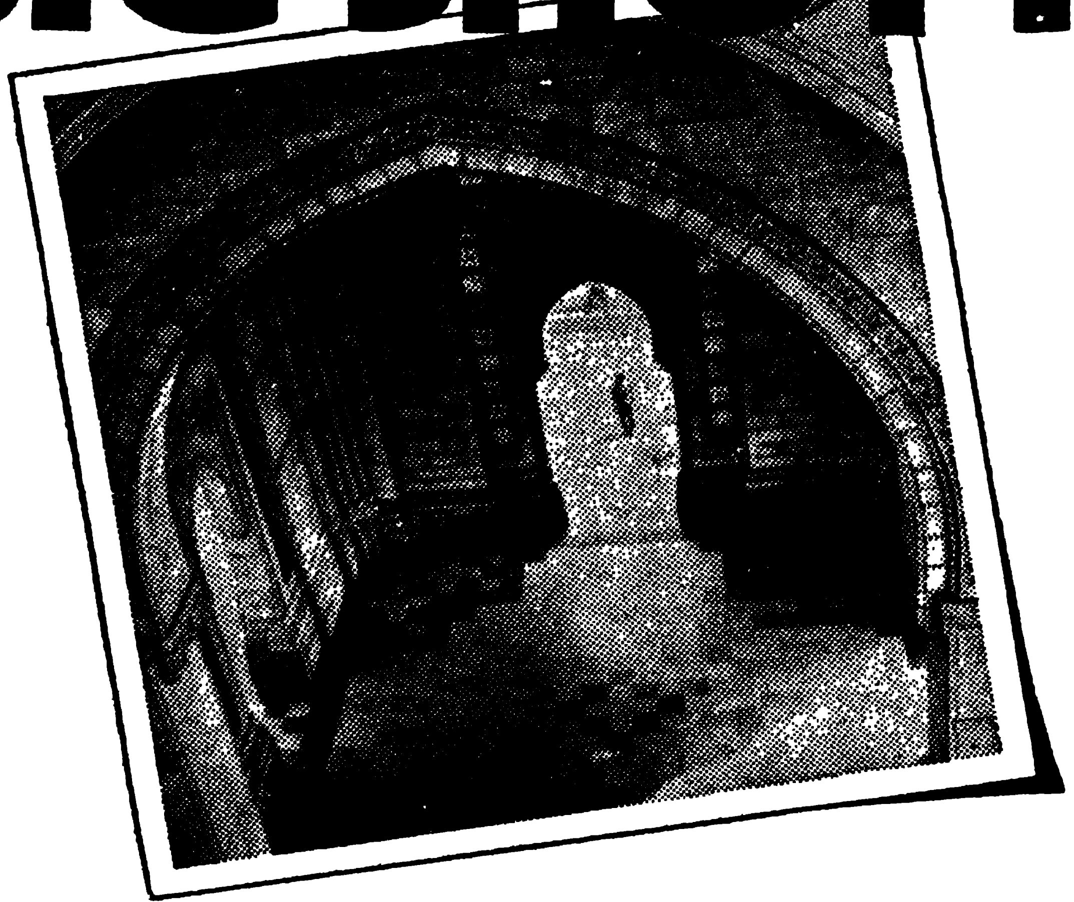
Annual Subscription Rs. 12·50

Single copy: Rs. 1·25; 2s

Editor
Surendr Jha

Printed and published for the proprietors Bennett, Coleman & Co., Ltd., by Pyarelal Sah at
Times of India Press, Bombay, India. Delhi Office: 7, Bahadur Shah Zaffar Marg, New Delhi
Calcutta Office: 13-1 and 13-2, Government Place East; London Office: 3, Albemarle Street, W

BIG SHOT!

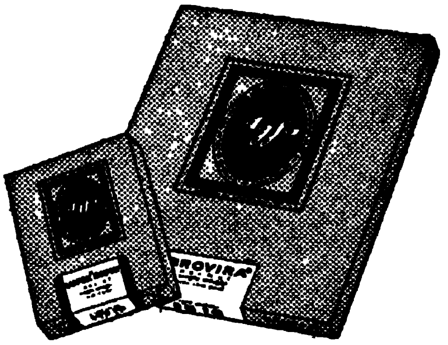


Agfa Photo Papers
put life into shots of any size

If you're really interested in photography, you're bound to be choosy about the quality of your prints and enlargements. So ask for the best. Specify Agfa Photo Papers. That way you'll never miss out on quality and tonal excellence.

For flawless results, it's

LUPEX—gives you sparkling prints
BROVIRA—gives you brilliant enlargements
Available at all authorised Agfa dealers
Made in collaboration with Agfa-Gevaert by:
The New India Industries Ltd., Bombay



Sole Distributors:
AGFA-GEVAERT INDIA LIMITED
Bombay • New Delhi • Calcutta • Madras

® Registered Trademark of Agfa-Gevaert Antwerp—Leverkusen. Manufacturers of Photographic Products

CMAG-133-300

ABOUT THE AUTHORS

H. M. BHATIA (*Blood Groups*) was one of the original discoverers of the 'Bombay' type blood in 1952. At present he is Officer-in-Charge of the Blood Group Reference Centre in Bombay.

Dr. Bhatia got his PhD in 1959 from Bombay University for his researches on blood groups. He visited Boston, USA, in 1961 as an international research fellow of the National Institute of Health (USA) and was Visiting Associate Professor at the Boston University School of Medicine from 1965 till 1967. During this time he worked on serological and immunochemical studies on agglutinins from seeds and snails and on the number of combining sites on 'A' group blood using seed agglutinins.

AJOY GUPTA (*Addictive Drugs*) is associated with a leading pharmaceutical company in Bombay. An MSc from Banaras Hindu University and a PhD from Bristol, he is a Fellow of the Royal Institution of Chemistry.

V. S. VENKATAVARADAN (*Interplanetary Matter*) is with the Geophysics Group at the Tata Institute of Fundamental Research, Bombay. A PhD from Bombay University, his research work includes cosmic-ray-produced activities in meteorites and Moon samples. He is a co-investigator with Prof. D. Lal of the TIFR on the Apollo-12 Moon rock samples.

STATEMENT ABOUT OWNERSHIP AND OTHER PARTICULARS ABOUT NEWSPAPER ENTITLED "SCIENCE TODAY" TO BE PUBLISHED IN THE FIRST ISSUE EVERY YEAR AFTER LAST DAY OF FEBRUARY, 1971.

FORM IV (See Rule 8)

1. Place of publication	The Times of India Press, The Times of India Bldg, Dr. Dadabhai Naoroji Rd, Bombay 1
2. Periodicity of publication	Monthly
3. Printer's Name	Pyarelal Sah for the Props: Bennett, Coleman & Co. Ltd.
Whether Citizen of India	Yes
Address	Rehmat Manzil, 2nd Floor, Flat No. 8, 75, Vir Nariman Road, Bombay 1
4. Publisher's Name	Pyarelal Sah for the Props: Bennett, Coleman & Co. Ltd.
Whether Citizen of India	Yes
Address	Rehmat Manzil, 2nd Floor, Flat No. 8, 75, Vir Nariman Road, Bombay 1
5. Editor's Name	S. K. Jha
Whether Citizen of India	Yes
Address	3-A, Somerset Place, Sophia College Road, Bombay 26

6. Names and Addresses of individuals who own the newspaper and partners or shareholders holding more than one per cent of the total Paid-up Capital as on 8-2-1971.

SHAREHOLDERS

1. Bharat Nidhi Ltd.,
   5, Parliament Street, New Delhi
2. Messrs Sahu Jain Ltd.,
   11, Clive Row, Calcutta 1
3. Jaipur Udyog Ltd.,
   Sawai Madhopur, Rajasthan
4. Messrs Sone Valley Portland Cement Co, Ltd.,
   11, Clive Row, Calcutta 1
5. Ashoka Viniyoga Ltd.,
   21, Esplanade Mansions,
   14, Government Place East, Calcutta 1
6. The Dehri-Rohtas Light Rly. Co. Ltd.,
   Dalmianagar, Bihar
7. Shri Ashok Kumar Jain,
   "Times House", 4th Floor,
   7, Bahadur Shah Zaffar Marg, New Delhi 1
8. Smt. Indu Jain,
   11, Clive Row, Calcutta 1

I, Pyarelal Sah, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Signature of Publisher
Sd/- P. L. Sah

Date: 1-3-1971

LETTERS

Newer Vistas

Dr. Bentley Glass, the retiring president of the American Association for the Advancement of Science, has declared in his speech that all major discoveries of science are over. It is heartening that equally eminent scientists like Dr. Glen T. Seaborg differ from him.

The contrary opinion, that science is still an endless frontier open to fascinating exploration and discovery, can be quite logically substantiated. We have only to approach science as the study of the phenomena of natural stimuli on the human senses to open amazing new vistas for scientific research. So far, major discoveries of fundamental character have been confined to natural stimuli — the sense of sight (light), the sense of hearing (sound), and the sense of touch (heat — probably electricity and its associated magnetism). Thus viewed, science has left totally untouched the physics of the stimuli affecting the sense of smell and the sense of taste.

The reason for the failure to probe into these virgin fields and to formulate laws governing these distinctive stimuli can also be surmised. Science is the measurement and generalisation of patterns and conclusions from emerging data. For measurement, an objective unit of measurement — smell and taste are still totally subjective — is a *sine qua non*. The absence of a unit of measurement for the stimuli of the senses of smell and taste is precisely what has kept the basic laws governing them still hidden in the treasure chest of nature.

There are, fortunately, at least two whole new worlds of science still awaiting discovery.

K. S. Rangappa
Editor, " Bhagirath ",
New Delhi

Owls

I think there is another explanation for owls leaving their nest-holes long before they learn to fly ("Owls", Science Today, January 1971). In lean seasons, hungry, " hole-dwelling " nestlings have been observed to eat their mates. The early dispersal of the young owls prevents this sort of cannibalism.

D. Ray
Varanasi

In our fourthcoming issues

CAN YOU MAKE A MACHINE SEE?

ALBERT EINSTEIN'S " FIRST " PAPER

CONDITIONS FAVOURING MAJOR ADVANCES IN SOCIAL SCIENCE

LOCUSTS — THE FLYING SCOURGE

PULSARS TO COLLAPSARS — FERMENT IN THE HEAVENS

AWARDS & APPOINTMENTS

A significant step towards reorganising India's electronics industry is the recent establishment of an **Electronics Commission** by the Government of India. The Commission, which is set up on the same lines as the Atomic Energy Commission, will have full executive and financial powers. The main function of the Commission will be: (*a*) formulation of policy, (*b*) preparation of annual budgets and (*c*) implementation of Government policy in all matters concerning electronics.

The Electronics Commission will consist of full and part-time members, whose total number will not be less than four and not more than seven. The chairman of the Commission will also be Secretary to the Government of India in the Department of Electronics and will be directly responsible to the Prime Minister.

Professor M. G. K. Menon, has been appointed Chairman of the Electronics Commission. He will continue to hold his present position as Director, TIFR, Bombay.

* * *

Dr. V. N. Shirodkar, gynaecologist, Bombay, has been awarded the Padma Vibhushan in the Republic Day Awards.

Among those who have been awarded the Padma Bhushan are: Mr. K. L. Vij, Chairman, Power Economy Commission, Central Water and Power Commission; Mr. M. N. Chakravarti, Chairman, Atomic Power Authority, Bombay; Dr. Satish Dhawan, Director, Indian Institute of Science, Bangalore; Dr. V. Ramalingaswami, Director, All-India Institute of Medical Sciences, New Delhi; Dr. Bishnupada Mukhopadhyaya, orthopaedic surgeon, Bihar; Mr. Madan Mohan Singh, cardiologist, Delhi; Dr. P. V. Sukhatme, Director, Statistics Division, FAO, Rome; Dr. Santosh Kumar Mukerji, physician, Madhya Pradesh; and Dr. Shantilal Mehta, surgeon, Bombay.

Among the Padma Shri recipients are: Dr. B. N. Balkrishna Rao, Professor of Surgery, All-India Institute of Medical Sciences, New Delhi; Dr. C. N. Krishna Murthy, Director, Textiles and Stores Research and Development Establishment, Kanpur; Prof. Devendra Lal, TIFR, Bombay; Dr. Harbhajan Singh, Indian Agricultural Research Institute, New Delhi; Dr. M. L. Dhar, Director, Central Drug Research Institute, Lucknow; Dr. S. V. Seetharama Shastry, Project Coordinator (rice), All-India Rice Improvement Project, Hyderabad; Dr. S. Krishnamurti, Director, Cancer Institute, Madras; Dr. Y. Nayudamma, Director, Central Leather Research Institute, Madras; Mr. Zafar Futehally, naturalist, Bombay; Dr. Hari Mohan, eye specialist, New Delhi; and Mr. T. V. Ramamurti, Deputy-Director, National Physical Laboratory, New Delhi.

On the Electronics Industry in India

K. P. P. NAMBIAR

ELECTRONICS as an industry has grown very rapidly since World War II, particularly after the transistor was invented in 1948. The pace has been further quickened by subsequent developments in the micro miniaturisation of components, printed circuits, integrated circuits and high-power semiconductor devices.

In consumer electronics, popularity of transistor radios, tape recorders, stereo-amplifiers, radio phonographs and monochrome and colour television increased the world output (excluding the communist countries) from worth about Rs. 4,150 crores in 1960 to Rs. 7,000 crores in 1967. This figure is expected to touch Rs. 15,800 crores by 1980.

In industrial electronics, the turnover of telephone and telecommunication equipment, broadcast equipment, measuring and control instruments, medical X-ray equipment, electronic calculators and data processing equipment jumped from Rs. 7,100 crores in 1960 to Rs. 17,000 crores in 1967. The projections are that by 1980 their world output may well be worth over Rs. 50,000 crores.

Similarly, the world manufacture of loose components like semiconductors, resistors, condensers, etc increased from Rs. 600 crores worth in 1960 to Rs. 935 crores in 1967. By 1980 it is expected to go beyond Rs. 1,700 crores.

What has been India's share in all these production figures? The total turnover of Indian electronic goods in 1969 was a mere Rs. 109 crores of equipment and Rs. 28 crores of loose components. These add up to about 2 per cent of that year's West European electronics output. Japan, the same year, produced Rs. 5,000 crores worth of electronic goods, raising it to Rs. 6,250 crores in 1970. And with a growth rate of 25 per cent, Japan by the end of 1975 is expected to produce goods worth Rs. 17,600 crores against the Electronics Committee's estimated Rs. 300 crores for India.

The keen interest of modern nations in electronics is understandable. Electronics has become a key factor in the economic operation of most of the basic industries. Generation and distribution of electricity, modern methods of production of steel, petrochemicals, machine tools and other such industries are today almost entirely dependent for their turnover and quality on electronics. Electronics is also vital for nuclear technology, mass communications, satellite or otherwise, and any system of modern defence. And, for capital-scarce, populous countries like India, electronics holds another panacea. The industry is more labour-intensive than capital-intensive, which means quicker industrialisation at least investment per person and a very large employment potential.

Why then has India fared so miserably in electronics? The explanation lies in the mode of growth of Indian electronics in the post-independence era. Electronics in India began with radios in 1949 with the establishment of two major radio manufacturing companies and, in 1954, with the setting up of India's first defence electronics factory. And a notable feature that characterised all these enterprises was that they were almost entirely based on foreign collaboration and/or equity participation. Even in 1969, out of a total turnover of Rs. 140 crores, nearly Rs. 50 crores of electronic goods accounted for radios, Rs. 60 crores for professional and defence electronic equipment and Rs. 28 crores for loose components, with the major part of activity confined to merely assembling the equipments and manufacturing components based on the blue-prints obtained from R&D labs abroad.

What is more, in most cases the technologies made available were those which had been obsoleted already in the West. Even companies like the Bharat Electronics Ltd were manufacturing in the late 50s and early 60s equipment that had been discarded by the British Army after World War II. In 1960, we were making radio valves, when 90 per cent of the radios in the Western countries were already transistorised. When we did, around 1962, finally start with transistors, all we did was to enter into foreign collaboration for the manufacture of germanium transistors. By that time the United States, Hong Kong and Japan had gone over to silicon planar transistors, and germanium devices for radio were fast reaching obsolescence in Europe too.

The foreign collaboration for the manufacture of semiconductor devices such as transistors and diodes invariably involved only the import of chips and encapsulating them in this country. The result was that these manufacturers also, like those of the electronics equipment industry, became just assemblers of devices. It was only recently that the government saw the error of this policy and pressurised the manufacturers to set up diffusion furnaces for the doping and diffusion of semiconductor materials.

Had a technological base been established in the country for the manufacture, and not merely assembly of parts, of even germanium transistors from 1962, it would not have been necessary to go into collaboration for silicon transistors in 1968 and for integrated circuits in 1971.

Our whole approach unfortunately, in this field, has been unabashedly shortsighted. We plumped for a quick turnover of obsoleted products ignoring the necessity of creating process-know-how capabilities inside the manufacturing organisations. While in Britain and the United States, almost the entire electronic equipment industry originated from small workshops with one or more design engineers, designing and developing an equipment after identifying applications and slowly building up an industry and growing into huge enterprises, in India we chose to work in reverse. We sought to establish an electronics industry by going straight for manufacture; industrial and import licences were used to produce goods which were readily available from foreign collaborators. It was not considered necessary, except in the case of national laboratories, to issue licences for the import of capital equipment or components to build up an indigenous R & D. It is as if we were trying to develop a unique Indian methodology in this field.

The colossal waste of foreign exchange due to foreign collaboration in the radio industry is something unbelievable. Take, for example, two most successful transistor radios in the country in the 60s, one a single band and the other a two-band transistor radio at an average price of Rs. 110 and Rs. 250 per set. Approximately half a million each of these have been sold corresponding to a turnover of about Rs. 18 crores. Taking 2 per cent as the royalty paid, this works out to Rs. 36 lakhs of foreign exchange drain. The development cost of the two radios together, if designed by local R&D, will be less than Rs. 2 lakhs. In fact, an R&D laboratory for the design of a whole range of radios could be set up with a capital involvement of Rs. 5 lakhs mainly for test instruments, and a recurring expenditure of Rs. 1 lakh for personnel and an equal amount for components and materials.

Let us face the facts: while some licensing agreement for critical and export-oriented items may be permissible for the time being, a real Indian electronics industry can be expanded and strengthened only by setting up R&D laboratories as nerve centres of the organisation. The first requirement is to identify the products we need for the consumer, the industry, the defence and the communication. Once this is done, the next step would be to start, on a massive scale, developmental activities in all those areas.

Are we competent to do this? Fortunately, India is not handicapped by any dearth of talents, and there are also many Indian engineers abroad who are thought of very highly by most companies for whom they have worked in the USA and Europe. Apart from the salary scales and a relatively satisfying professional environment, the main attraction for them to stay abroad has been the speed with which one's ideas can be implemented, through ready availability of materials, components and equipment which are essential to conduct experiments and achieve results.

It is in providing these facilities and an enlightened, dynamic, progressive and objective management that we have miserably failed. Whenever it comes to the question of establishing an industry, we think in terms of huge plans, deployment of hundreds of crores of rupees over a period of 10 years, possibility of loans, collaboration, etc etc. To my thinking it is a most lopsided approach. For example, in the Electronics Committee report it is said that we will produce Rs. 1,650 crores worth of goods in 10 years between 1965 and 1975. We might as well say Rs. 16,000 crores in 20 to 30 years. What significance do these figures have? If one understands the electronics industry clearly, it does not take too much time to realise that what will be produced at the end of 10 years or even in the fifth year will be quite different from what was initiated in the first year. The nature of component, circuit, system, equipment, technology, and plant and machinery itself change so fast that totalling of production over a period of 10 to 20 years has no more practical significance than in saying that one will draw a total salary of Rs. 8 lakhs in 30 years.

The cumulative figures of production over a number of years in place of yearly targets and rate of growth serve only to frighten away the entrepreneur. The main question is whether we can create viable and resources-wise self-generating units which can develop electronic components and equipment in the industrial, consumer and defence areas, manufacture them, rotate the inventory by sales and invest the necessary funds in the R&D with a view to updating the designs, and refining them continuously in keeping with the latest sophistications in the technology.

The electronics R&D laboratories that exist in India today present a most disappointing picture. Imagine the Central Electronics Engineering Research Institute of Pilani displaying at exhibitions in Delhi in 1969, 1970 and 1971 transistor radios, portable and mains operated, when for the last 10 years the entire radio industry, including its thousands of smallscale units, have been already designing radios which are more economic and with better tried-out performance characteristics. Even as late as 1971, the Pilani Institute is working on TV service instruments and camera systems using germanium transistors which were obsoleted 10 years ago. The National Aeronautical Laboratory, one presumes, was set up to look into the aerodynamic problems, electronics instrumentation of aircraft and other allied problems relating to aviation. Should we rejoice that this laboratory has just completed a design for an electronic desk calculator for use in offices when a number of licences or letters of intent had already been issued by the government for manufacture of calculators with indigenous knowhow ?

One would have expected a slightly better state of affairs in the private sector. But here, too, the picture is as dismal. In the case of smallscale industries, inadequate finances have resulted in slow growth; their scarce resources did not permit import of expensive test equipments or the employment of competent engineers on adequate remuneration. The foreign companies were of course not interested in the indigenous development; they were busy, as I said before, assembling old and almost obsolete designs from abroad with an eye for quick returns on investment. And the larger Indian industries? They, until very recently, were not attracted to this field, one doesn't know whether it was because of inexperience or lack of interest. Most of the top management of large enterprises were concerned with basic industries only, such as textiles, jute, bicycles, automobiles, synthetics, chemicals, steel, electricity and sugar, most of which were established by pioneers of an earlier generation. The few who attempted to enter into even the conventional radio industry met with limited success only.

The key to the growth of the electronics industry in India is in the immediate establishment and encouragement of R&D laboratories in all sectors, private and public, with clear-cut, well-defined short-term and long-term objectives. And an essential requirement of such an R&D setup would be provision of sufficient resources to buy sophisticated test equipment and raw materials from India and abroad, to hire young, enthusiastic and qualified engineers, and to establish pilot plant facilities.

Industries with sufficient financial resources can set up the R&D with twin objectives — one, to manufacture equipment designed by the R&D in their own works, and the other, to give know-how to outside agencies — mainly smallscale entrepreneurs — on royalty basis. Mushrooms of industries centred round a single R&D laboratory could also be built in different parts of the country. These laboratories can be the designing, testing and technical service authority for the electronics units in a particular industrial estate.

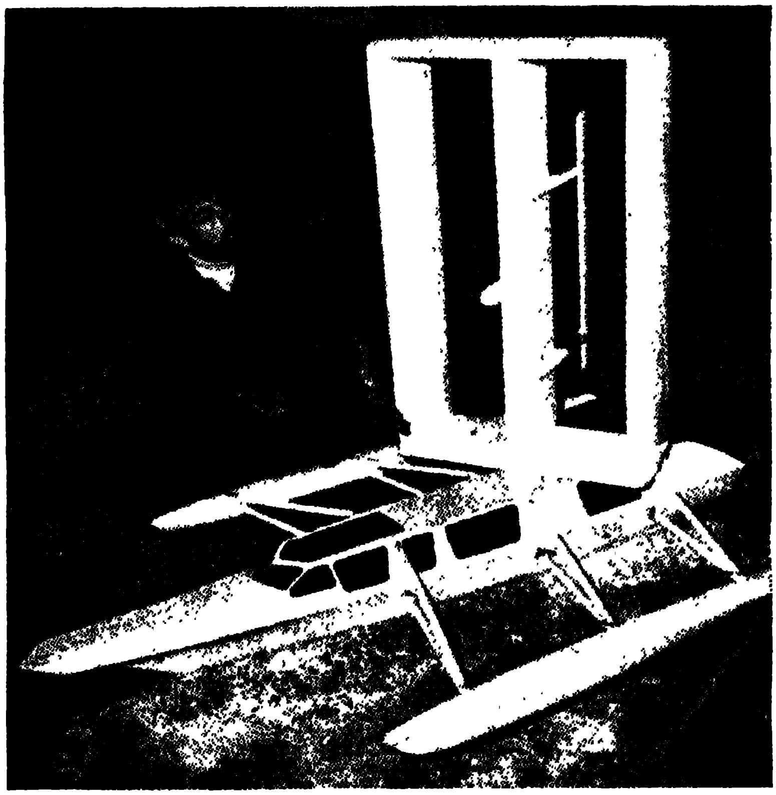
If a programme is drawn up on this basis, and implemented swiftly, a firm base for the electronic industry throughout the country can be laid. There are, of course, human problems to be resolved, especially in the choice of management, R&D and marketing personnels. But if we proceed with an open mind and clear-cut objectives, these problems can be satisfactorily resolved.

The government must take the first step. It must encourage the labs by generously granting licences for the import of raw materials and vital components like integrated circuits, silicon-controlled rectifiers, samples of equipment manufactured abroad, etc, and it must do it expeditiously. Let us not wait for two years after applying for licences by which time the project as well as the components and equipment may become obsolete. Do we realise that, from the setting up of a small development group and growing into a Rs. 5 or even Rs. 50 crores enterprise it takes the British or American entrepreneurs on an average 2 to 3 years, approximately the time it takes to obtain an industrial licence from the date of application in India?

Let the government also acquire a more informed approach. Must it, for example, continue to insist that a licence for R&D equipment will be given only after a manufacturing licence is obtained? If we are serious about establishing an electronic industry, let us learn from our past mistakes and take bold and objective steps which will ensure that the annual turnover of electronics products will be at least Rs. 600 crores by 1975. as against Rs. 300 crores forecast by Dr. Bhabha in his famous report 5 years ago.

K. P. P. Nambiar is head of the R&D laboratories of the Tata Electric Companies. A pioneer in the semiconductor circuit technique, Mr. Nambiar has been connected with the transistor circuit design since as early as 1954 as a post-graduate student at the Imperial College of Science and Technology, University of London, where he was awarded the MSc degree for his work on transistor timing and computing circuits in 1957. He had his theoretical and practical training in the UK and USA. He spent over twelve years in London and at the time of his return to India in 1963, was Chief Applications Engineer of Transitron Electronics Ltd, UK.

SCIENCE SHAPES LIFE



AEROFOIL TRIMARAN

A new trimaran (model above) is being built by a British firm. The four-ton craft, called " Nova ", is 16·5 m long, 9 m high and has special aerofoil sections to form the sails which will make it fast and easy to handle. The sails are almost exactly like aircraft wings.

The " sails " are operated entirely from the cockpit by a Boeing-style lever incorporating joystick and throttle, permitting single-handed sailing. The aerofoil sections fold down hydraulically and the crossbeams at the side fold in to make " Nova " narrow for easy handling.

EARLY TEST FOR CANCER

Researchers at Israel's Hebrew University claim to have developed a new blood test which detects cancer at an early stage. The test is based on the presence or absence of a protein, T-globulin, in the blood; the protein, it is reported, is found only in cancer patients and pregnant women. In tests on 520 persons, 356 of them were found to have this protein factor in their blood, and each turned out to be a cancer patient or pregnant.

Israeli scientists plan to do mass screening for cancer using this method. But researchers elsewhere expressed doubts whether the test could be applied to people in other areas of the world.

NEANDERTHAL MAN AND RICKETS

Is the Neanderthal man closely related to apes? Or is he really a respectable ancestor of man? Recent studies have been in favour of the latter opinion (Science Today, November 1968). A recent research report suggests that the Neanderthal man was not at the end of the evolutionary process; his apish looks were caused by rickets.

Evidence for this comes from studies of the Neanderthal teeth, bones and skull. X-rays revealed the ricket ring patterns in bones. All Neanderthal child skulls had a large head, high forehead, patches of defective bone, etc. The bones of children showed the " bowing " of rickets. Adult bones were softened by Vitamin D deficiency. The report says that the Neanderthal man had very little of Vitamin D, his diet having been meat, shellfish and vegetables. Nor did he have much access to sunlight since he lived far from the equator and in a glaciation period.

INSOLUBLE LEAD DIOXIDE ELECTRODES

The production of chemicals such as chlorates, perchlorates, bromates, etc involves the use of graphite or platinum electrodes which are also consumed in the process. Efforts have been going on for the development of indestructible anodes either as a substitute for costlier anodes or to increase the life of anodes used in the electrochemical industries. The Central Electrochemical Research Institute, Karaikudi, India, claims to have developed graphite substrate lead dioxide electrodes which can be used as insoluble anodes for the production of inorganic chemicals such as chlorates, perchlorates, bromates, iodates, periodates and in some of the organic oxidation processes.

The anodes have a very adherent and smooth deposit of lead dioxide free from pores; this protects the graphite substrate. The deposition of lead dioxide on the graphite substrate also serves as a good electrical contact. Electrodes of any size can be made easily by the choice of a substrate of proper dimensions and by depositing thin coatings of lead dioxide to thicknesses ranging from 2 mm to 5 mm.

Besides prolonging the life of graphite in oxidation processes, the lead dioxide electrodes will help to dispense with the use of costly platinum as anodes in the preparation of perchlorates. Using graphite substrate lead dioxide anodes, the CERI has achieved single stage oxidation of chloride to perchlorate.

The cost of depositing 1 sq cm area of 1 mm thick lead dioxide has been worked out at Rs. 2·85, excluding the cost of graphite. The process has been patented.

THE WORLD OF THE MYNAHS

Who hasn't heard the mynah's mockingly imitative sounds? They brought a British scientist, Brian Bertram, all the way to the jungles of Assam to study the vocalisation of Indian wild mynahs. According to a report in *Nature*, mynahs imitate human beings because human whistles and low-pitched voices are similar to those of mynahs.

Each wild mynah has a set of 5 to 12 different calls. Some of these are common among mynahs of the same sex living in the same area, forming a "distinct local dialect confined to one sex." And though the birds mostly live in pairs, they never imitate their mates; each has a different set of calls.

Do mynahs imitate other birds? Strangely, no. Young mynahs do imitate their adults. Despite the differences in their calls, mynahs seem to have some way of recognising calls from their own species. And they can even tell when a mynah is new to a place; the stranger's calls are not imitated.

CONTROL FOR X-RAYS

Radioactivity from X-rays can accumulate in the body and too much exposure can cause harm. Present-day X-ray tubes emit some unwanted rays which are in no way helpful because they fall out of the film. A new X-ray tube, devised in the US, has a collimator which cuts out such random rays by limiting the beam to the exact size of the film. This has another advantage: with less exposure one gets a sharper picture.

GUARD AGAINST FRANKENSTEINS

There are times when scientists begin to shudder when faced with the implications of their experiments. An example of this was the control of nuclear fission and the consequent development of the atomic bomb. Some months ago, a group of scientists from the New York State University Centre for Theoretical Biology, USA, assembled a living amoeba from components drawn from many similar cells (see Science Shapes Life, December 1970). The amoeba proliferated in hundreds, setting off speculations that eventually life could be tailor-made this way. The leader of the team, Dr. James F. Danielli has now pleaded for a national or international check on such work to prevent any likely misadventures. It may soon be possible to synthesise self-sustaining biological systems, he predicts. In that case, what is the safeguard against the development of strains that "could prove disastrous to living things"?

COMPUTERS FOR CREATIVE ART

Computers can take much of the drudgery out of a designer's work of draughting. Magazine layouts are now visualised through computers; a new system, being developed at the University of Utah, USA, promises to bring relief to the architect. By simply tapping the keys of a

ROAD TRANSPORT FOR THE FUTURE

Though traffic congestions in big cities have been getting worse, the road transport system has basically remained the same. Two new plans worked out by German firms promise to bring relief to the road and to passengers, reports *New Scientist* in one of its recent issues.

One of these is to run small plastic cabins, resembling roller-coasters and with 2 to 3 seats and enough room for luggage, electrically in a network. All that a passenger has to do is to drop a punched or magnetic card, which he gets on selecting his destination on a map, into a slot beside his seat; the cabin then automatically follows a fixed track to the place without stopping on the way. Stations are built off the main track to avoid hindrances. As the cabin approaches the station, it automatically turns in a gentle curve to the siding. A central computer keeps a watch on the network and sends empty cabins to all stations. The cabins can run at a speed of about 50 kmph with a gap of 10 to 20 metres between two cabins. The system operates in addition to the existing system without interfering with it.

The cabin can run aerially on support poles, along the sides of buildings, underground tunnels, at the sides of roads or on the middle of the road on two-way roads. Being small, it can take passengers right into large buildings like railway stations and airports.

The second system is based on the container-carrier principle, with small one or two-seat containers. Here also the passenger only chooses his destination on entering the cabin; everything else is automatic. The cabin is slid into the bus or train in the station and is slid out again at the destination. The passenger either walks out of the cabin if he wants, or it automatically proceeds on the onward journey to the exact destination.

computer, he can get his plans sketched on a cathode ray screen. The blueprint can be modified, altered, rotated or magnified at will as the architect develops his ideas mentally.

The details of the plans are stored in another computer. When the architect finalises the design, it puts together all the details to produce a photograph of the plan. Relieved of routine drawings, a good designer can become better, says the programmers of the new system. The programme, however, is part of a bigger study on how computers can help solve creative problems.

ELECTRIC ROCKETS

Ion thrusters, or electric rockets, are likely to provide propulsion in future long-range space flights. They have a long life and cost less. In this system, a beam of photons, an intense beam of light, provides the thrust instead of the present chemical rocket thrusters. However, rocket thrusters may still be needed to lift the spacecraft off the ground as the thrust needed for this is much higher than the ion thruster can give. But in space, where the spacecraft doesn't have to travel against the gravitational force, the ion thruster could be extremely efficient; it can be used continuously with a gradual speed build-up.

A NASA test of a satellite-borne ion thruster, designed to operate for six months, failed after five months owing to an electrical short circuit. After studying the cause of this failure, engineers are now designing new crafts to avoid this fault.

SOURCE OF INTELLIGENCE?

A study by the Medical School Mental Retardation Centre, University of California, Los Angeles, USA, indicates a relationship between the size of the placenta in rabbits and the intelligence of the offspring. Researchers found that the larger the placenta, the larger the baby rabbit at birth and the size and weight of the brain. If intelligence could be related to the ratio between the body weight and the brain weight, a bigger brain size could result in higher intelligence.

HOLDING BACK HIJACKERS

Drama high in the air is no doubt exciting; a gun-gripping passenger coolly hijacking an aircraft from the US to Havana makes interesting reading. But not so when it is nearer home. Not, in any case, when the plane is blown up for no reason. The hijackers are now here. And within days after an Indian Airlines plane was taken to Lahore and dynamited last month, IA and the police got busy acquiring gadgets to foil future aspirants. What are the various devices available?

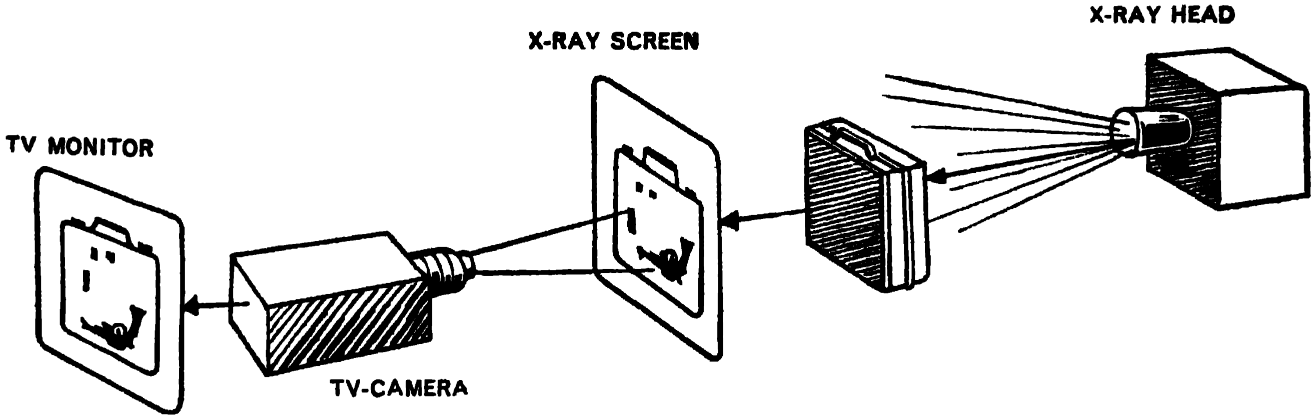
In the US, where air piracy has become almost routine, most airlines use a system developed by the Federal Aviation Administration. It begins with watching the passengers' behaviour. Keen-eyed guards posted at various points in the airport look out for a particular behavioural pattern among passengers. Lest hijackers are forewarned, the details are not disclosed. But psychological studies by US Federal scientists did show that hijackers fall into a recognisable pattern of behaviour.

When a passenger behaving suspiciously is spotted, the message is passed round, and the person is made to walk through a weapon-detection station on the way to the departure gate. The detector is a magnetometer. But the passenger doesn't have the faintest suspicion as it is specially designed as a walk-through; only a metre wide, it permitts only one person at a time. Concealed in the two metal poles of the walk-through are eight magnetometers — four in each pole. A monitor connected to the poles interprets magnetometer readings When a passenger with a weapon or any ferrous metal walks through the device it flashes a blue light. This is because the detector responds to the disturbances in the earth's magnetic field caused by any iron or steel object, and the magnetic field of the steel object itself; the message is passed on to the monitor which amplifies it to switch on the blue light. The magnetometer is so sensitive that it responds even to small weapons. But the snag is that 50 per cent of the passengers carry enough harmless iron or steel items to set off the device. So only those passengers previously found suspicious are retained for interrogation; their number is only 5 per cent of the total metal carriers.

Meanwhile, an X-ray eye which can see through a bag has just been developed by an American firm, and may be used as a third test. In this test, the X-ray eye, using short pulses, produces a sharp picture of any weapon hidden in a briefcase on a TV monitor screen.

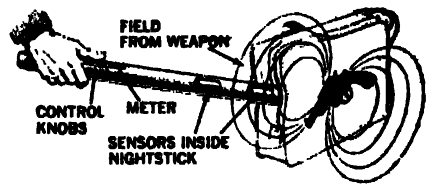
The fastidious Japanese seem to have gone a step ahead. In an all-metals detector system, they make the passengers walk through an electrical coil concealed in a rectangular pipe

A police officer tries out a 'detectron', the new anti-hijacking equipment acquired by the Special Branch for use at Santa Cruz airport



The X-ray eye uses tiny doses of radiation — 50 billionths of a second exposure — to produce an X-ray image of a bag's contents on a fluoroscope-type screen. The image is viewed by a TV camera and displayed on a monitoi screen for inspection

The nightstick magnetometer (right) can pinpoint the location of a weapon in the baggage



frame. Any metal object moving across the coil sets up an induced current in the coil which triggers an alarm circuit; three red lights indicate the nature of the metal object — one for a knife, two for a pistol and three for a large firearm. Of course, the object may turn out to be a harmless metal article. Britain uses a different version of this system.

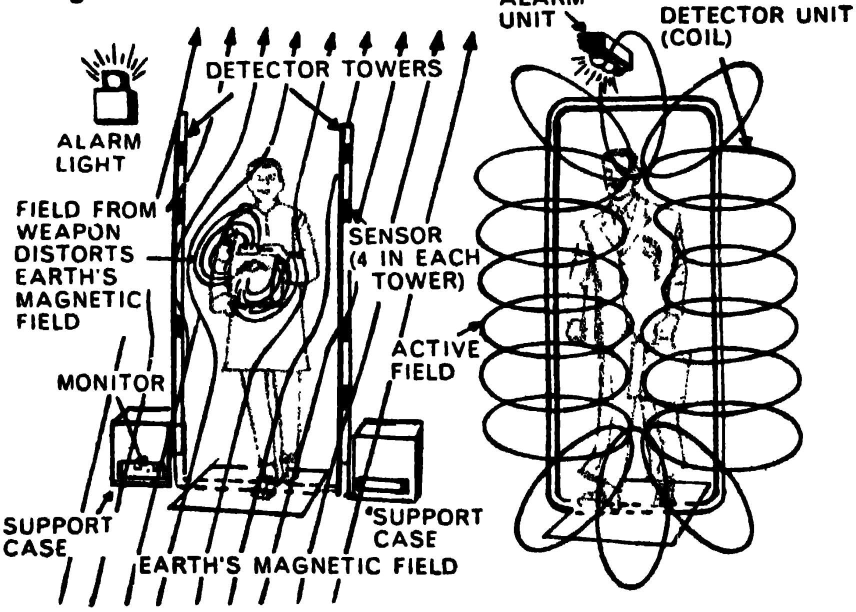
So much for guns and revolvers. Research has now turned towards detecting explosives. And with West Asia fast catching up with the US in air adventures, El Al, Israel's national airline, has tried a " bomb sniffer " which smells characteristic vapours from some explosive chemicals. Ethylene glycol dinitrate from dynamite is an example of such vapours.

Nearer home, Indian Airlines plans to screen passengers and luggage with X-ray cameras fitted at the aircraft entrance. Its stewards may also be given electronic nightsticks that can detect concealed arms; the innocuous-looking stick doesn't raise the hijacker's suspicion.

The Bombay police also have become alert, though prompted more by bomb scares during VIP flights. At the Santa Cruz airport in Bombay, they are already using a " detectron." In this, the search head, a two-tier disc, responds to the presence of metals and relays the message to a transistorised box with an indicator on it. A continuous strong tone, similar to a telephone's busy tone but stronger, tells of the presence of a metal. The police are also considering the installation of the walk-through type detectors.

But what if the hijacker walks past all these preventive barriers and gets aboard? The only safeguard here so far is closed and bullet-proof cockpits. This is what Air India plans to use. Though not bullet-proof, its cockpit doors will remain closed to hijackers.

The weapon detection station (left) has a magnetometer which senses disturbances in the earth's magnetic field when a weapon passes between the detector towers. The active field metal detector (right) creates its own magnetic field and signals when a weapon carried through disturbs it



ROENTGEN REVOLUTIONIZED MEDICAL TECHNOLOGY BY DISCOVERING X-RAY

November, 1895. A German Physicist conducting tests in his darkened laboratory, observed that a paper screen containing barium-platinocyanide emitted an extraordinarily brilliant fluorescent light. The Scientist paused...More tests followed...Roentgen discovered the X-ray — a "super" ray with such a small wavelength that nearly a hundred million waves measured just one centimetre! This gave it the unique power of penetrating even opaque substances.

Roentgen's discovery of X–rays revolutionized medical technology. Today, X–rays serve humanity not merely in hospitals, but in industries, scientific laboratories and research institutions.

We, at BEL, manufacture four types of X–ray tubes for the medical profession. Plans are currently on hand for the production of X-ray tubes for use in industry and in research institutions.

Every day in many ways BEL serves you better and better

BHARAT ELECTRONICS LTD.
Regd. Office· JALAHALLI-BANGALORE-13

AIYARS-BEL-710

Top : Fig. 1 Zodiacal light seen from mountain altitude. This is caused by the scattering of Sun's light by interplanetary dust particles

INTERPLANETARY MATTER

V. S. VENKATAVARADAN

" It has long been an axiom of mine that the little things are infinitely the most important." Sherlock Holmes was definitely talking of earthly things. But had his creator been an astronomer, he would have included outer space too. Talking of the solar system, one usually talks of the Sun and the planets; yet the most important clues to its origin and history are surprisingly contained in comparatively little things like the asteroids, comets and interplanetary dust

ASTEROIDS! Comets! Interplanetary dust! How do these minor objects fit in with the general regularity of the solar system? Do they represent primitive material from which the Sun and the planets were formed or are they just pieces of a broken planet? There are a number of theories as to the origin of the solar system which can be divided basically into two groups: one group consists of catastrophic theories which require either a grazing collision of a nearby star with the Sun or a violent explosion of a companion star of the Sun. Less catastrophic is the hypothesis that the Sun passed through a dense interstellar cloud from which the planets were evolved.

The other group — the passive theories — tries to explain the planets as merely by-products o star formation. Stars are formed from vast cloud of interstellar gas and dust — which may be ligh

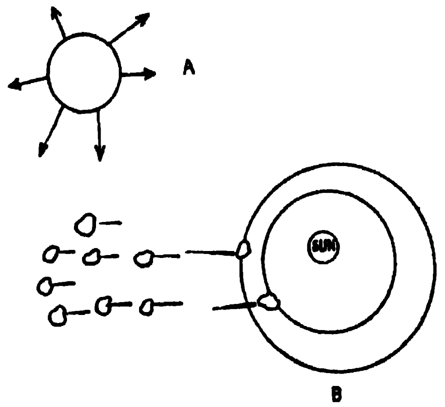
Planets	*Predicted distance by Bode's Law (Astronomical units)*	*Measured distance (Astronomical units)*	*Radius of the planet (kilometres)*	*Mean density*
Mercury	0·4	0·39	2,500	5·3
Venus	0·7	0·72	6,200	4·95
Earth	1·0	1·00	6,370	5·52
Mars	1·6	1·52	3,350	3·95
Asteroids	2·8	2·1 to 3·5	——	——
Jupiter	5·2	5·2	71,200	1·33
Saturn	10·0	9·5	60,300	0·68
Uranus	19·6	19·2	23,800	1·56
Neptune	38·8	30·1	22,000	2·47
Pluto	77·2	39·5	About 6,000	?

years in dimension (many are visible in our won galaxy; the Orion nebula is one) by gravitational contraction. The normal gas density between stars throughout the galaxy is about one-tenth of a hydrogen atom per cubic centimetre volume (which means that about one gram of matter is distributed in a cube whose sides are each about 2,000 kilometres long), while in the star-forming clouds, it could be as high as 1,000 H atoms/cm^3. When the dust and gas condense to form the central star, some material is left out to form the planets and satellites.

Irrespective of whether the theories belong to the active or passive group, both comets and asteroids pose a problem regarding their origin. Most planets have nearly circular orbits and their distances from the Sun are found to increase in a regular pattern given by what is known as "Bode's Law". The Law is an empirical one and goes like this: Add 0·4 to the series of numbers 0, 0·3, 0·6, 1·2, 2·4, 4·8 9·6, 19·2, etc which leads to 0·4, 0·7, 1·0, 1·6, 2·8, 5·2, 10·0, 19·6 and so on. If the unit of distance is taken as the distance from the Sun to the Earth (1 A.U.), the first four numbers represent the positions of Mercury, Venus, Earth and Mars while the last three agree with those of Jupiter, Saturn and Uranus.

Asteroidal belt

However, one finds a planet missing between Mars and Jupiter at 2·8 A.U. Later it was found that the region between Mars and Jupiter is filled with innumerable small objects. These are the asteroids and the region is known as the asteroidal belt. It is believed to have been caused by the disintegration of an original planet. The mean distance from the Sun to the asteroidal belt is very near to that predicted by Bode's Law. So far there is no clear-cut explanation for Bode's empirical law. Some consider this as a mere coincidence while others think that there is some physical principle underlying the distribution. (It must be noted that the Law deviates very much in predicting the distances of Neptune and Pluto; see table above).

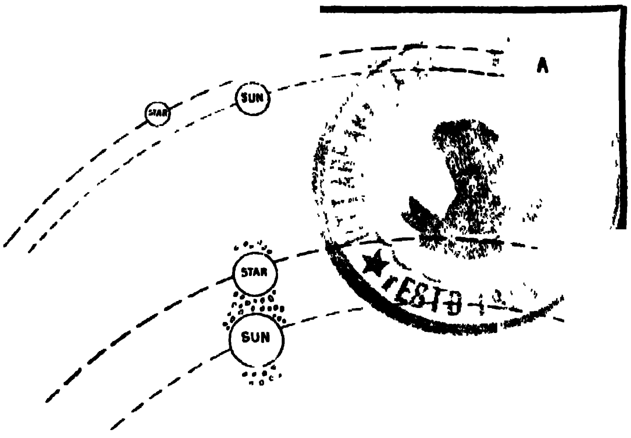


How the planets formed

HOYLE'S theory proposes that a star near the Sun might have blown up, throwing off a large shell of material, possibly more in one direction than in others. This is called a Nova and it is a frequent occurrence in the stellar systems. While the Nova recoiled away from the Sun due to the one-sided explosion, part of the Nova shell could be caught by the Sun's gravitational field to form the planets.

The asteroidal belt extends from 2·4 to 3·6 A.U. About 2,000 asteroids have been detected by telescopes while a large number of them must lie below the detection threshold, ie are too small to be detected. Most travel in orbits of low eccentricity and their orbits lie outside the orbit of Mars with orbital periods of 4 to 7 years. Some of them have more eccentric orbits and cross the orbit of Mars at perihelion and some like Eros cross even the Earth's orbit.

Four asteroids, namely Ceres, Pallas, Vesta and Juno, appear as discs of light when observed through a telescope. The others appear merely as dots of light. The diameters of the larger four range from about 193 kilometres to 770 kilometres. By an analysis of the reflected light (albedo, colour and polarisation), it may be concluded that they are made up of solid rocky material similar to the terrestrial planets. Extrapolating the observation regarding the reflectivity etcetera to the smaller objects, one may conclude that there are about 14 asteroids of diameter larger than 100 kilometres, about 300 asteroids whose diameters are larger than 30 kilometres and about 2,000 whose diameter exceeds 17 kilometres. A much larger number in the smaller diameter range are expected to be present even though they can not be directly observed. Extrapolating the trend observed for the larger asteroids to the smaller ones, one estimates that there are about a million asteroids greater than 1 kilometre and a million million objects larger than 7 metres. Even with such a colossal number, the total mass of the asteroids comes to only about 3 per cent of the mass of the Moon.



CHAMBERLIN-MOULTON theory: A passing star narrowly misses the Sun causing huge eruptions on both stars. The Sun is left with a vast number of planetismals condensed from the erupted gases later to form the planets. The intruding star also may have formed its own planetary system.

KANT'S theory: According to this theory the gas and dust condensing to form the Sun leave behind clots of nuclei which grow by accretion to form planets and satellites.

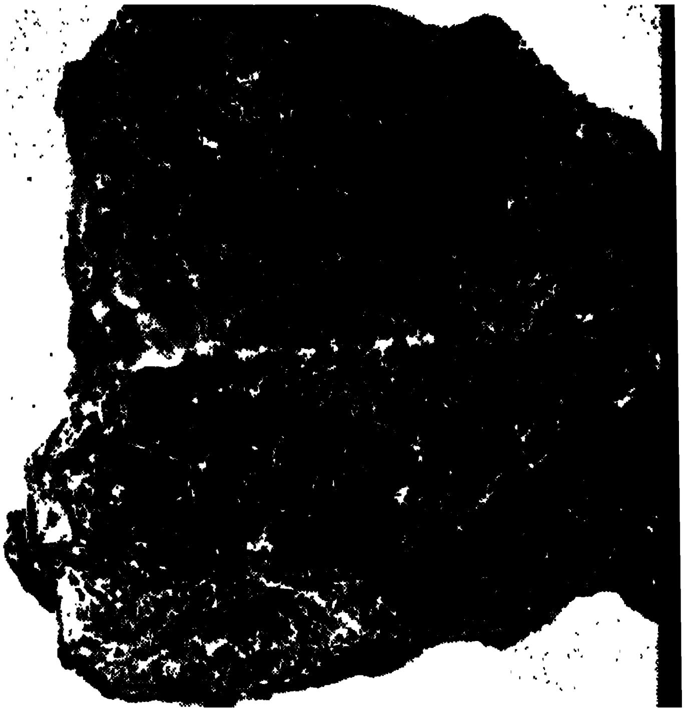


Fig. 2 A fragment of Orguell meteorite showing white vein of magnesium sulphate running horizontally across the specimen. This vein must have deposited from water solution thus offering evidence of one time presence of liquid water in the meteorite parent body

Asteroids are irregular bodies as observed from their intensity variations. While spinning in space, they appear brighter when they show their broad faces to the telescope; the narrow face gives a dimmer image. Actual measurement of the irregularity was possible in the case of the Earth-crossing asteroid Eros. It was found to be about 22 kilometres long and 6 kilometres wide. The irregular shapes are taken as an evidence of the breaking up of an original planet. However, some scientists consider the asteroids to be primitive material in a planetary formation stage and not a disintegrated planet.

Meteorites

Since the asteroids have orbits which often intersect one another, collisions should be comparatively frequent. This process may be responsible for the production of meteorites and interplanetary dust. Piotrowski, a Polish astronomer, has calculated that the collisions would create several thousand million tons of fine dust and rubble.

The objects that cross the Earth's orbit are captured by the Earth's gravity and most of them are burnt off as meteors when they pass through the atmosphere. If the objects are sufficiently big, parts of them are recovered as meteorites. Meteorites contain in them a lot of information regarding the origin of the solar system. Their elemental composition and mineralogy would depend on the environmental conditions in which they were formed (such as the temperature and pressure, availability of free oxygen and water, etc and also changes in the environment at a later time). Figure 2 shows one fragment of the Orgueil meteorite with a vein of magnesium sulphate running across the specimen. This vein must have been formed by deposits of water solution thus offering evidence of the one time presence of liquid water in the meteorite parent body.

The ages of the meteorites which were recovered on Earth were determined by radioactive dating methods and were found to be about 4·7 billion years, i.e. as old as the Earth itself (and also as old as the Moon as recently determined from the study of lunar rocks from Apollo missions) showing that these objects condensed into solid bodies around the same time, viz. 4·7 billion years ago.

Fig. 3 The tracks seen in the meteorite crystals give clues to the history of meteorites and cosmic rays in the past. The tracks are caused by stopping nuclear particles from cosmic rays. They are also produced by spontaneous fission of uranium and plutonium. Uranium fission tracks can be used to date the object, while the plutonium fission tracks are used to find out the cooling time of the planetary bodies (similar to the Xenon method)

By analysing the decay products of comparatively short-lived radioactivities like iodine-129 (halflife—16 million years) and plutonium-244 (halflife—76 million years), it is possible to decipher the time interval between the cessation of nucleosynthesis (the stellar cooking of elements) and the condensation of the planetary bodies. Iodine-129 decays into Xenon-129, while plutonium-244 fissions spontaneously giving rise to heavier Xenon isotopes. After the end of nucleosynthesis, the amount of these radioactivities present will go on reducing with time. (During the period of nucleosynthesis, the amount lost due to radioactive decay will be compensated by the fresh production of these isotopes). If the meteorites cooled earlier, they would contain more of the Xenon isotopes. If they cooled after a long time (long compared to the mean life of these isotopes), there would be less of the Xenon isotopes. An analysis of the Xenon isotopes present in meteorites makes it possible to estimate the time of solidification of the meteorite parent bodies.

The meteorites were exposed to cosmic rays from the time they got separated from their parent bodies until they were captured by the Earth. Thus detection of radioactivities produced by cosmic rays gives information about the flux of cosmic rays in the past. It was found that the cosmic ray intensity has been nearly constant over the past billions of years.

Another ingenious experiment by D. Lal and R. S. Rajan made it possible to pinpoint some of the ‘original dust grains’ which later condensed to form the meteorite parent body. The technique is as follows: the primordial dust grains were exposed in space and were constantly bombarded by the solar wind and solar flare particles in space. The flare particles are capable of causing crystal damages of a few microns on the surface of the dust grains which are exposed to the energetic particles. These defects can be chemically etched and seen under an optical microscope as tracks of a few microns. When the meteorite parent bodies were formed, only a small fraction of the dust particles were heavily exposed to the flare particles, the rest of them being shielded. By picking out grains (from the interior of a meteorite) which have an unusually large number of tracks, one can understand the history of the solar flare particles during the beginning of the solar system. (A similar study in lunar dust and rocks made it possible to understand the history of solar flares over millions of years in the past.)

As mentioned earlier, meteorites in general are assumed to come from the asteroidal belt. Until now, at least a class of meteorites were suspected to have come

Tunguska Meteor

The most spectacular meteor fall of recent times occurred on 30 June 1908 in the basin of the Tunguska River, Siberia. It was seen in a sunlit cloudless sky over an area of about 1,500 km in diameter and was described as the flight and explosion of a bright fire ball which " made even the light of the Sun appear dark ".

Visible phenomena were observed from a distance as great as 700 kilometres and loud explosions were heard at distances up to 1,000 kilometres. The fall caused magnetic disturbances similar to those recorded following nuclear explosions in the atmosphere.

After the fall of the meteor, the nights were exceptionally bright everywhere in Europe and Western Siberia. As far south as the Caucasus, newspapers could be read at midnight without artificial light. The brightness slowly diminished and disappeared after a few months. (If the fall had occurred in India over, say, Bombay, the visible effects would have been seen as far away as Madras, Mangalore, Jaipur and Karachi.)

Since no residue of meteoritic matter was found in the region of the fall, it was assumed to be cometary in origin. The high energy release also posed a problem even for a cometary origin. In the case of comets there exists an extra source of energy (in addition to the mechanical impact) which is the chemical dissociation of unstable compounds like hydrogen peroxide (which are stable at low temperatures but become unstable due to the heat of impact).

It was also thought of as an antimatter impact. The annihilation of matter and antimatter could give rise to enormous energy which could simultaneously explain the absence of meteoritic material. However, it is not conclusively proved that it was antimatter in origin. It is more likely that it was of cometary origin.

from the Moon (this is ruled out after the analysis of lunar samples). Could it be possible that the meteorites came from the comets? Some scientists think so.

Comets

Comets are unique objects in the solar system, quite unlike planets or asteroids. Their orbits are highly eccentric. Some of them have orbits which are elongated ellipses with their perihelion (closest distance to the Sun) near the orbit of Earth or Mars and their aphelion (farthest distance from the Sun) beyond the orbit of Jupiter. These are known as periodic comets (appearing at regular intervals). Other comets have orbits which are parabolic, reaching distances in interstellar space up to a light year or so. Usually they appear only once and disappear for ever. Several hundreds of these non-periodic comets have been observed and recorded over the past many years. Comets have both proragrade (similar to the planets) and retrograde (opposite direction to those of the planets) orbits and they are not confined to the ecliptic like the planets or asteroids.

A comet is indeed a beautiful sight in the sky (see Fig. 4). It has its central nucleus surrounded by a head (in diameters up to a million kilometres) and a tail which is much longer compared to the head and may extend to about 20 to 30 million kilometres. They are mainly made up of gaseous and microscopic dust particles. Compared to the head and the tail, the nucleus is a tiny object only a few kilometres in dimension. It reflects sunlight and appears as a bright spot in the centre of the coma. The nucleus is made of ices of various compounds like ammonia, water and dust and larger solid particles which Fred Whipple of the Harvard college observatory calls " a dirty snow ball ". The comet does not possess its typical head and tail structure when it is far from the Sun. The head appears when the comet comes closer to Jupiter's orbit and the prominent tail begins to appear when it crosses the orbit of Mars. The evaporation of the solid ice material when they approach the Sun is responsible for the appearance of the head and the beautiful tail. When the comet nears the Sun it sheds small solid particles as well as gases and the Sun's radiation pressure pushes the smallest of these particles away from the Sun forming them into a dust tail. Thus the combined effect of radiation pressure and gravitational force gives birth to the curved dust tail. In contrast, the gas tail is a streaming straight one.

The size distribution of the particles comprising the dust tail may be estimated from the polarisation of light and it is inferred to be of the order of one thousandth of a millimetre.

Losing the tail

Comets lose matter everytime they pass near the Sun. Finally, when all their gaseous and dusty matter is gone, the solid central core alone will remain which will be somewhat similar to a small asteroid. E. Opik of Armagh Observatory has proposed that some of the asteroids in the asteroidal belt are made up of such dead comets. H. J. Oort of Leiden Observatory has proposed that there is a belt of cometary bodies around the Sun about a light year in radius. Due to the perturbation of neighbouring stars, they enter the closer regions of the solar system to be seen as comets. Some others believe that the comets condensed in the outer regions of the solar system during the time the solar system itself was formed.

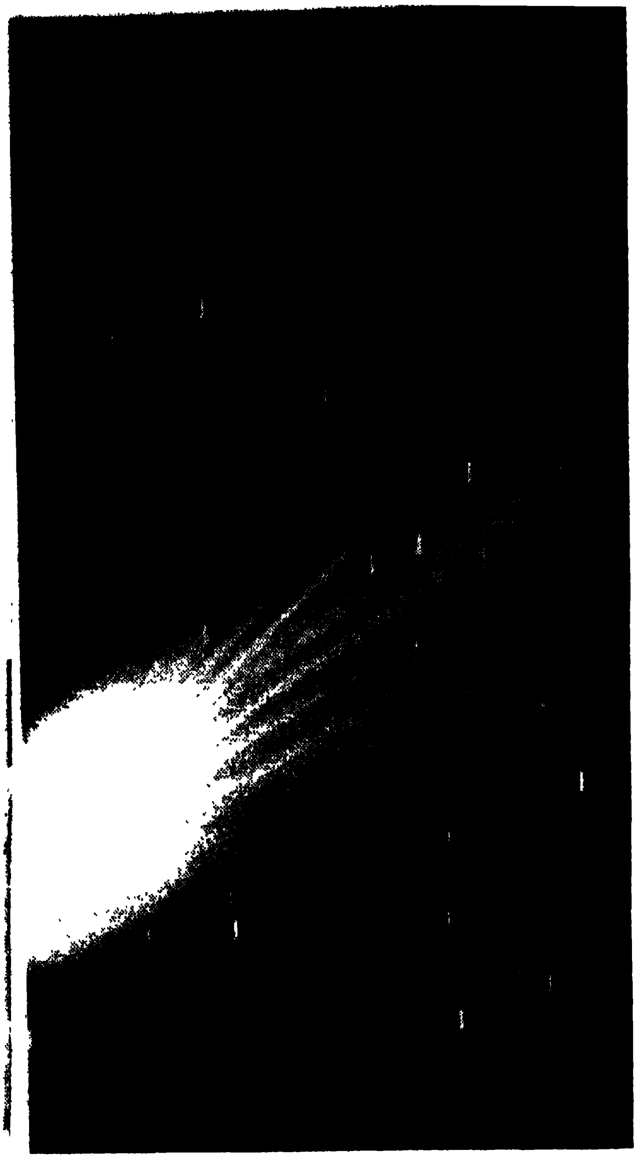


Fig. 4 Comet Mrkos 1957 discovered on 2nd August 1957. The vertical lines in the background are stars which have moved during the exposure

If one compares the densities and composition of terrestrial planets (up to and including Mars) and Jovian (beyond and including Jupiter) planets with those of asteroids and comets respectively, one finds that the asteroids resemble the terrestrial planets in having a high density typical of rocky material while the comets, on the other hand, resemble the Jovian planets in having high abundance of gaseous material with low density. It may be that the Jovian planets formed from predominantly cometary material and the terrestrial planets from asteroidal material.

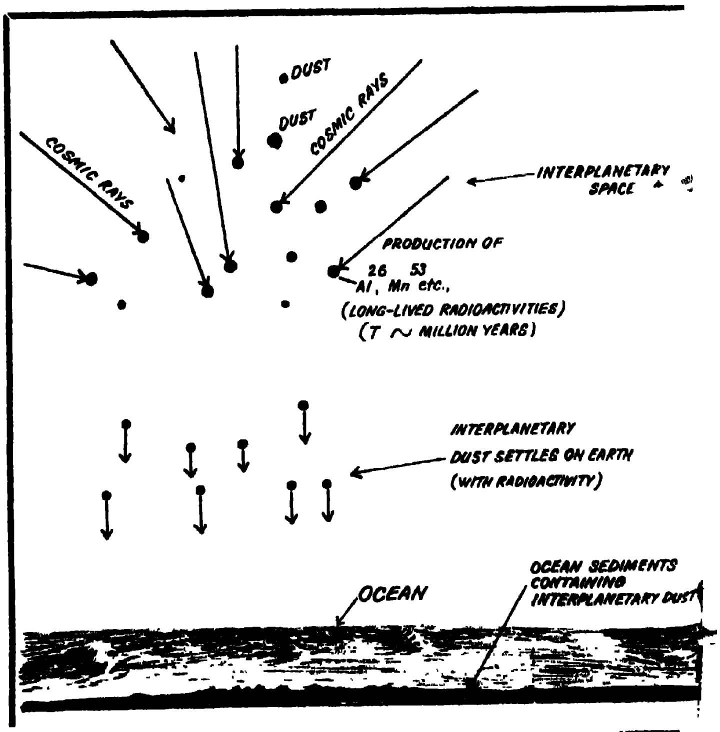
It is known that meteor showers are observed when the Earth crosses orbits of known periodic comets. This is due to the flight into the atmosphere of residual material left by the passing comet. Whipple has estimated that the comets shed about a thousand million tons of dust into the solar system each year which is comparable to the estimated asteroidal dust production. Thus both the minor planets in the asteroidal belt and disintegrating comets as they approach the Sun contribute to the mass of interplanetary dust. If the dust particles are too small (less than one part in a million million of a gram), they are thrown out of the solar system by solar radiation pressure. If they are sufficiently big, they spiral in towards the Sun due to what is known as Poynting-Robertson Effect. This is a sort of drag effect in the radiation field of the Sun. The presence of solar plasma enhances this effect. They are finally captured by the Sun and get evaporated or, alternatively, are captured by planets as they intercept them.

Zodiacal light

The solar corona and the zodiacal light also give evidence for the existence of dust particles in interplanetary space. From a spectroscopic observation of the solar corona it is possible to infer a dust component (F-corona).

Zodiacal light is produced by the scattering of Sun's light by interplanetary particles (mainly in the region of 0–1 A.U.). The zodiacal light may be observed on a dark night as a faint band of light oriented along the ecliptic and increasing in intensity towards the Sun (Fig. 1).

When the zodiacal dust particles are intercepted by the Earth, they are captured by the Earth's gravitational field. It is very difficult to identify



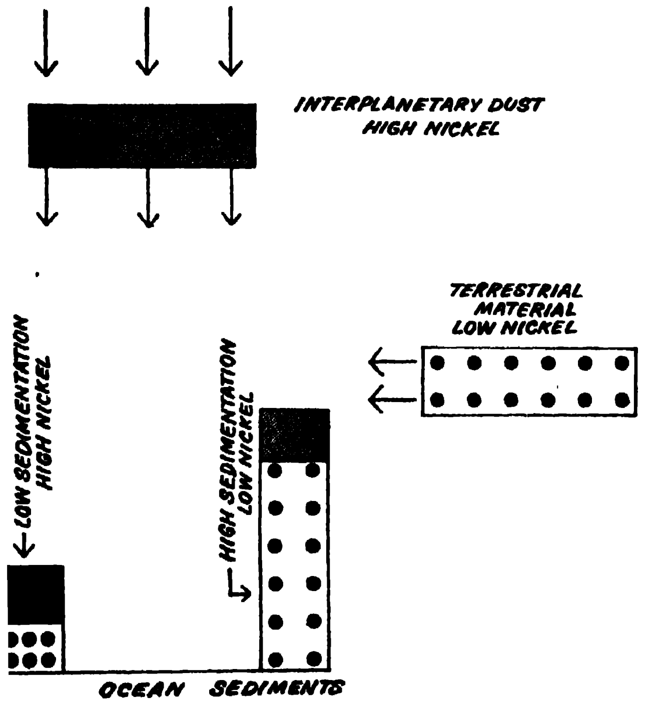
these particles as they are polluted by terrestrial material. However, scientists have looked for signatures of these extraterrestrial particles in deep ocean sediments and in polar ice where the terrestrial contamination is expected to be minimum. It is known that the meteorites (and hence probably the interplanetary dust) are enriched in nickel (by a factor of 200), iridium and osmium (by factors of few thousands). The amount of nickel (or iridium or osmium) present in, say, deep sea sediments will give the amount of influx of interplanetary dust into the Earth during the period of sedimentation. It was found that in places where the sediments accumulated rather slowly, the amount of nickel was found to be high and vice versa. This is possible only when an extraterrestrial source for nickel is presumed.

Another more specific attempt to look for interplanetary dust in deep sea sediments was made by a team (B. S. Amin, S. G. Bhat, D. Lal and the author) at the Tata Institute of Fundamental Research, Bombay. This consisted of looking for radioactivities (like Al^{26} and Mn^{53}) produced in interplanetary dust (which subsequently gets deposited in ocean sediments) by cosmic rays. These activities are highly specific in that these are not produced in appreciable amount in the Earth's atmosphere. A measurement of the radioactivities in conjunction with the sedimentation rate gives the influx of interplanetary dust into the Earth. The above methods gave a value of about 1,000 tons per day for the global influx of interplanetary dust. Recently the study of lunar dust from Apollo missions have also provided information about the interplanetary dust which agrees with the terrestrial measurements.

Alfven, the 1969 Nobelist in Physics, and Arrehnius have proposed a mission to land a space vehicle on an asteroid to bring back material from there. This, they believe, would give further clues to the understanding of the solar system. However, some others (like John A. Wood) believe that it would be more exciting to do it on a comet. Wood feels that the asteroids would most probably look like meteorites in which case one does not learn much; however, the comets are expected to be different from any object — terrestrial or extraterrestrial — studied so far and hence will be much more useful in understanding the solar system. This will of course create enormous technical problems, although they may be minimised by choosing a favourably close approach of the comet towards the Earth. The material thus retrieved may indeed be the primitive material of the solar nebula which condensed from the interstellar space. The non-periodic comets have stayed for quite sometime in the interstellar space in recent time and hence will give information about space as it exists now.

Icarus

Icarus is an asteroid about 1·5 km in diameter and it misses the Earth by about 6·5 million km during closest approach. The chances of its approaching much closer is nil. However 6·5 million km is a comparatively small distance in the solar system. If Icarus were to collide with Earth, it would produce a crater of about 15 to 25 km in diameter. The energy involved would be the equivalent of 500,000 megatons of TNT (100 times more intense then any of the recorded earthquakes). If the strike occurred on land, the blast would level trees and buildings within a radius of several hundred kilometres and some 100 million tons of soil and rubble would be thrown into the stratosphere where it would reside for tens of years reducing the solar radiation received by the Earth which might trigger an ice age. How is it possible to prevent such a catastrophe? One solution might be to destroy it by sending a space vehicle with nuclear detonators. Another method might be to deflect it from its course by landing a rocket engine. The problem was posed to students of systems engineering at MIT, Cambridge, Massachusetts, USA, during 1967 (Icarus was to intercept the Earth on 19 June 1968). The students came out with fantastic solutions which have been published as *MIT Report No. 13 — Project Icarus*, Ed. — Louis A. Kleiman, MIT Press.



Red blood cells contain one or more antigens. The serum has antibodies that attack alien antigens. Blood is, therefore, grouped according to the presence or absence of particular antigens in it

BLOOD GROUPS

H. M. BHATIA

IN ordinary appearance, it is just a spot of red. But under the microscope, a drop of blood presents a strange world of red cells, white cells, tiny platelets and the liquid serum. The serologist's trained eye traces the difference from drop to drop. And on each sample he sticks a label — A, B, O . . . In the 70 years since Landsteiner first spotted four different blood groups in 1900, at least 13 well-defined groups have been found. Many more are under the microscope, waiting to be labelled.

Outside the human body, blood turns into a jelly within 8 to 10 minutes; this coagulated blood cannot be transfused. In 1914, Hustin observed that coagulation can be prevented if blood is collected in a specific amount of sodium citrate. Blood thus collected could be transported or preserved in liquid state at cold temperatures for 3 to 4 days. This discovery was useful in handling large samples of blood during World War I. Later, it was found that the addition of glucose to blood preserved it for 14 days. This was extended to 3 to 4 weeks during World War II with a preservative containing sodium citrate, citric acid and glucose (ACB). This is the method now commonly used in blood banks all over the world, including India.

However, longer preservation of blood still engages the attention of researchers, and new preservatives are being tried. A solution containing citrate-phosphate-dextrose (CPD) has been found to stretch the preservation period to 6 weeks at 4°C. Also, the addition of a purine derivative, adenosine, increases its stability. But with special procedures, and in a frozen condition, blood can now be preserved even up to 2 to 3 years. This method is particularly useful in the case of some rare bloods as they are otherwise not easily available in an emergency. But no such facilities exist in India because of the high cost of imported equipment like the —70°C deep freezer or liquid nitrogen containers, though we often have patients of the rare " Bombay " type for which donors are few and, in any case, not available on hand Often, frantic appeals for this blood are flashed through newspapers and the radio. Other rare types of blood like Ry and Lw—negative in the Rh system, Tj (a—) and Mg (a+) are also found in India. Demands for them are likely to arise in future.

Professional donors

The collection of blood is a simple procedure, taking only 10 to 15 minutes for drawing 300 to 500 ml from the arm vein. This much loss of blood is well tolerated by the body and the donor can go about his normal work immediately after. But what is not so welcome is the increasing number of professional donors; about 60 per cent of the blood collected in Bombay comes from professionals. Their blood may not cause complications in transfusion but it is certainly of a poor quality and may even spread diseases. A stronger propaganda for voluntary donation and an awareness of the uses of blood may help in avoiding this.

Blood is needed in several disease conditions. And to increase its utility generally the appropriate blood traction is used—red cells (erythrocytes) without the plasma in cases of severe anaemia; the liquid portion, plasma or serum, in cases of burns where there is a loss of blood fluids; and whole blood in cases of severe blood loss or in major operations like heart and brain surgery. Other fractions like white cells (leukocytes), platelets (small cells other than red and white) and plasma fractions like gamma globulins, albumin, fibrinogen and anti-haemophilic factors are transfused in other disease conditions. The lack of fractionating plants in India restricts the production of plasma fractions and the efficient use of the packed cells; there is at present only one such plant in the country.

But then blood cannot be transfused freely from one person to another. With the help of radio isotopes, it is now known that the normal life of red blood cells is 120 days. The transfused blood should remain in the patient's circulation for this period, if it is compatible. If not, antibodies in the patient's blood destroy the donor's red cells quickly, sometimes within an hour, leading to severe ill-effects like rigors, high fever and pain in the back and chest. The rapid destruction of red cells will also cause the accumulation of haemolysed (broken) blood pigments in the circulation and urine. Since the kidneys in the normal state can excrete only a small amount of haemolysed blood, the excess amount impairs their functioning.

Blood groups

So, for transfusion, the compatibility of blood is first ascertained. This is done by antigen-antibody reaction tests. The red cells in blood contain antigens; the serum contains antibodies which attack alien antigens (see "What Is So Strange about Blood?" SCIENCE TODAY, July 1968). Blood is, therefore, grouped according to the presence or absence of particular antigens in it. A person with A antigens in his blood forms group A and with B antigens, group B; the presence of both A and B antigens is

HAEMOLYTIC DISEASES IN THE NEWBORN

Jaundice in newborn infants is associated with anaemia; if untreated, it may cause death. In severe cases, the bilirubin pigment gets deposited in the tissue and damages the brain, resulting in mental retardation. In some cases, infants develop very severe anaemia during intra-uterine life and some even die (stillborn). It is now known that some of these cases are caused by the reaction of the antibodies in the mother's serum against the antigens in the infant's blood. Most often, it is the Rh_0 (D) antigen which is involved in maternal immunisation. In cases where the woman lacks this antigen or is Rh negative and her husband is Rh positive, the children are likely to be Rh positive. During the first delivery, a small quantity of the infant's blood gets into the mother's circulation, provoking Rh antibody formation. In subsequent pregnancies, these antibodies, if of a smaller molecular size, cross the placental barrier and destroy the infant's red cells. Haemolytic disease due to Rh is not thus common in the first pregnancy. As a rule, the pattern of the disease is the same for all other blood group antigens except for the A or B antigens which could possibly affect the first infant. Another feature of haemolytic diseases in the newborn due to the ABO group is that it is encountered in A or sometimes B group children of the O group mother.

The blood of the newborn children suffering from this disease gives a positive reaction to the Coombs test which detects the coating of maternal antibody globulins on the infant's red cells. The severity of the disease is best judged by the strength of the maternal antibody and the Coombs test reaction, the severity of anaemia and a high concentration of the bilirubin pigment. It is also possible to predict the severity before the delivery by examining the amniotic fluid (fluid in the foetal sac).

The treatment for the disease lies in the removal of such red cells coated with antibody. This is done by exchange transfusion; Rh negative blood is given to the infant and an equivalent amount of the infant's blood is removed. The earlier the treatment, the better are the chances of survival. In very severe cases, where the child may die before birth, intra-uterine transfusion may help.

However, not all Rh negative individuals exposed to Rh antigens, either from blood transfusion or from bearing Rh positive children, produce Rh antibodies. The reason why only a few develop antibodies is not yet clear. Several factors like heredity or immunological tolerance are considered. In Europe, one out of every 200 newborn babies develops haemolytic disease; in India, it is one out of 700 to 800.

Though biologically one cannot prevent the immunisation of Rh negative women, some of the recent attempts have been successful. These include the elimination of Rh positive foetal cells from the mother's blood circulation after delivery by administering purified globulins with very high titre anti-Rh. The efficiency of this new approach will be known in the coming years. Though it may not completely eliminate the disease, this approach may at least reduce the number of such cases.

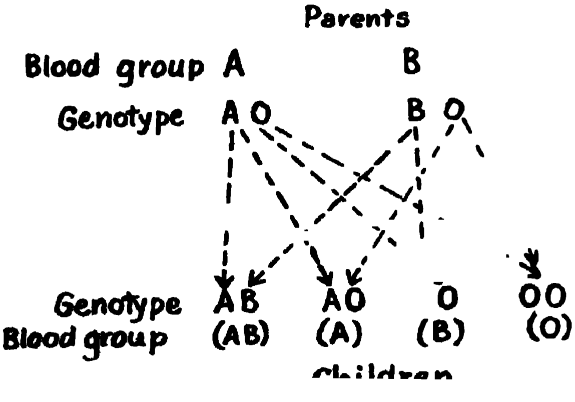
group AB and the absence of both group O. These are common antigens; when some special or rare antigens are found, they form special groups, like the "Bombay" group which we shall discuss later. Several special groups have been found, some of them more likely to be within particular families.

From over 60 antigens, most of which were discovered in the last 25 years, 13 blood group systems have been worked out. They are (with the number of antigens in each group in brackets): ABO (3), MNS (23), P (2), Rh (18), Lutheran (2), Kell (1), Lewis (2), Duffy (2), Kidd (2), Diego (2), Yt (2), I (2) and Xg (sex-linked on X-chromosome) (1). Besides, there are 33 other antigens yet to be classified. The Blood Group Reference Centre in Bombay, established in 1957 by the Indian Council of Medical Research, has identified many rare bloods and antibodies. The Centre serves as a national reference laboratory for blood groups.

Red cells of group O are not attacked by antibodies, and the serum of AB people does not act on any donated red cells. (So the former have been called "universal donors", and the latter "universal recipients"). Though, theoretically, incompatibility is undesirable, it may not cause serious ill effects if the recipient has no antibodies against the particular antigen in the donor's blood. But there is one danger. The transfusion may provoke the patient to develop antibodies (immunisation) and subsequent transfusions may cause reactions.

Next to the ABO groups, the Rh antigen, the antigen common between the Rhesus monkey and human beings, is clinically the most important. Ninety-five per cent of the Indian population have Rh antigen in their blood, while it is 85 per cent for Europe. Rh antibodies are produced in individuals who lack them (Rh negative) if they are given Rh positive blood, and in Rh negative women if they bear Rh positive children. And of all immunisations, 95 per cent is against Rh antigens. Once this immunisation occurs, transfusion of Rh blood leads to severe reaction. In women, it will cause jaundice in their Rh positive newborn infants (see box on p 23). Therefore, it has become a routine practice in many of the blood banks and maternity centres to do Rh tests.

Fig. 1 The pattern of genetic inheritance in the ABO system. The child inherits a gene each from either parent; the combination decides the blood group



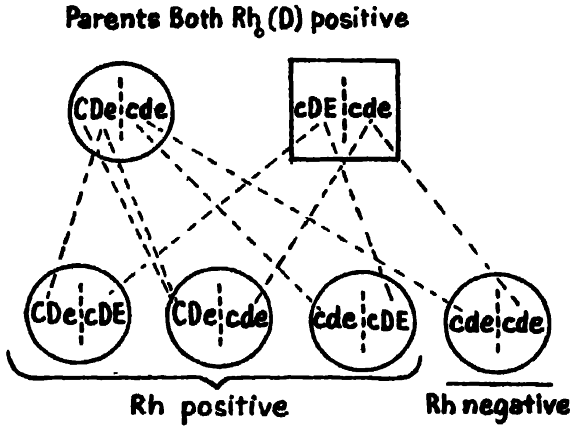


Fig. 2 Rh blood group inheritance pattern. Antigen D is common in all Rh persons and usually decides this group. D gene exists in various combinations with Rh sub-antigens. Note the following features: (*i*) antigen d is only hypothetical since no antigen has been recognised; (*ii*) there is a theoretical controversy whether the associations of different Rh antigens, C or c, D or d, E or e, are due to three allelic genes very closely linked or they are a cluster of different types of antigens resulting from one gene; and (*iii*) several combination genes could occur. But the most common ones are CDe, cDE and cde. Some of the rare combinations are Cde cdE, cDe, CDE and CdE

In the Rh system, there are several antigens known as sub-types of Rh. However, only one of them, Rh_0 or D is important, being present in all persons classified as Rh positive. And immunisation against antigen D is more common than against other Rh sub-type antigens.

Inheritance pattern

Most of the blood groups follow a simple mode of genetic inheritance. In the ABO system, there are altogether three allelic genes (allelic genes occupy a particular position—locus—on the chromosomes). Gene A forms antigen A, gene B forms antigen B and gene O contributes no antigen. An individual possesses only two of these genes, inherited one each from either parent. And the combination of these two genes decides his blood group. The genes may be similar or different. Thus, from 3 genes, the ABO group people form 6 genotypes — AA, AB, AO, BB, BO and OO. Since gene O contributes no antigen of its own and since no antibody reacts to it, both genotypes AA and AO form blood group A, and similarly both BB and BO form blood group B. Genotype AB leads to blood group AB and OO to group O. Evidently, parents belonging to blood groups A and B can have children in any of the four blood groups (see fig. 1). If both the parents are in group O, they cannot have A or B children; A and O parents will have children in either of the two groups and so will the B and O parents.

There are, of course, further sub-divisions of the A and B antigens. But from the laboratory point of view, these represent the weakness of the antigens and are known as weaker variants of A and B. Such A and B variants have been detected in India, though their distribution is not yet known. Inheritance of most of these variants also follows a straight path down generations; there are cases where the weaker variants do not follow this simple inheritance pattern.

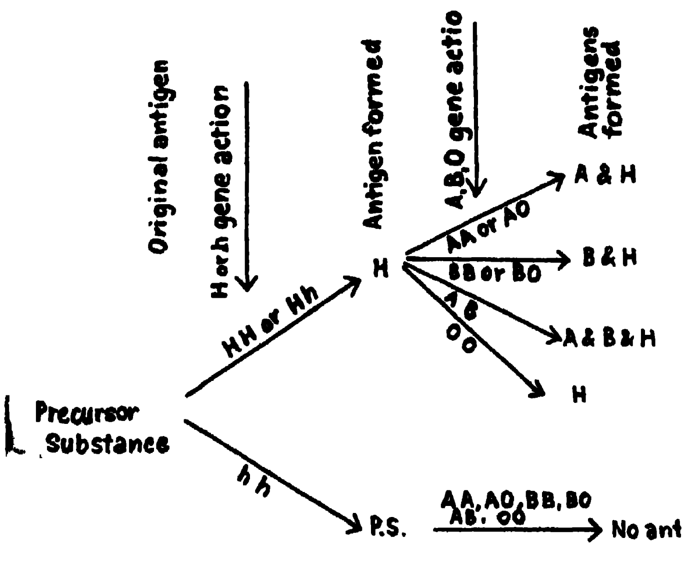
The inheritance of other blood groups is equally simple. For example, though several antigens are known in the Rh group, inheritance is straight forward (fig. 2). However, there are examples where the accepted simple inheritance is not tenable. And interestingly, in all such cases one or the other rare type blood is involved. For example, in 1952 a rare type of blood within the ABO system was discovered in Bombay. But before discussing this group we should know how the ABO blood group antigens are formed by the action of genes; this has been inferred from studies of Bombay group families. The basic raw material here is a chemical, not clearly identified yet, known as the precursor substance; its conversion into antigens takes place in two stages. First, a gene known as H (different from the A, B, O genes), which is present in a pair or a combination with another gene h in most of the ABO people, converts the precursor substance into the basic H antigen. Any of the six ABO genotypes mentioned earlier then acts on the H antigen and converts it into corresponding A or B antigens or, in the case of genotype AB, both. The basic H antigen remains as a part of all groups. And since gene O forms no antigen blood group O has only the H antigen. Fig. 3 shows how the 5 blood groups, including the "Bombay" type which we shall now proceed to discuss, are formed.

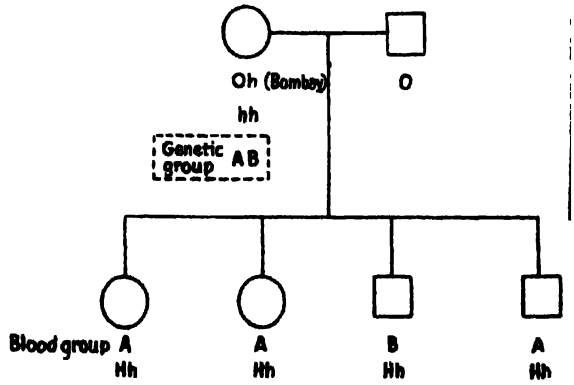
"Bombay" group

The "Bombay" blood apparently belongs to group O, but it lacks the basic H antigen. Accordingly, it has an extra anti-H antibody which reacts with all other bloods except the "Bombay" blood. Though rare (1:13,000 people in western India), it is more frequent in India than in other countries. Family studies of this group suggest that it does not possess the H gene needed for converting the precursor substance into the basic H antigen; instead, it has a pair of h genes. And though it may possess normal A or B genes, the corresponding A or B antigens are not formed for lack of H antigen. It is, therefore, possible that these Oh type (Bombay) persons may genetically belong to any of the O, A, B or AB groups; only family studies will reveal this. AB gene actions, which remain suppressed in the "Bombay" parents, will reappear in their children possessing H genes. Thus in the family shown in fig. 4 the "Bombay" group woman and her husband both are apparently of group O and, therefore, could

Fig. 3 (left) Stepwise gene action in changing precursor substance to basic H antigen and then into A and B antigens on red cells, on the basis of which blood groups are formed. Note that in the Bombay group the H gene is missing and, though A and B genes may be present, no antigens are formed

Fig. 4 (right) Inheritance in "Bombay" group. A and B gene actions suppressed in the "Bombay" group mother reappear in the children who possess H genes





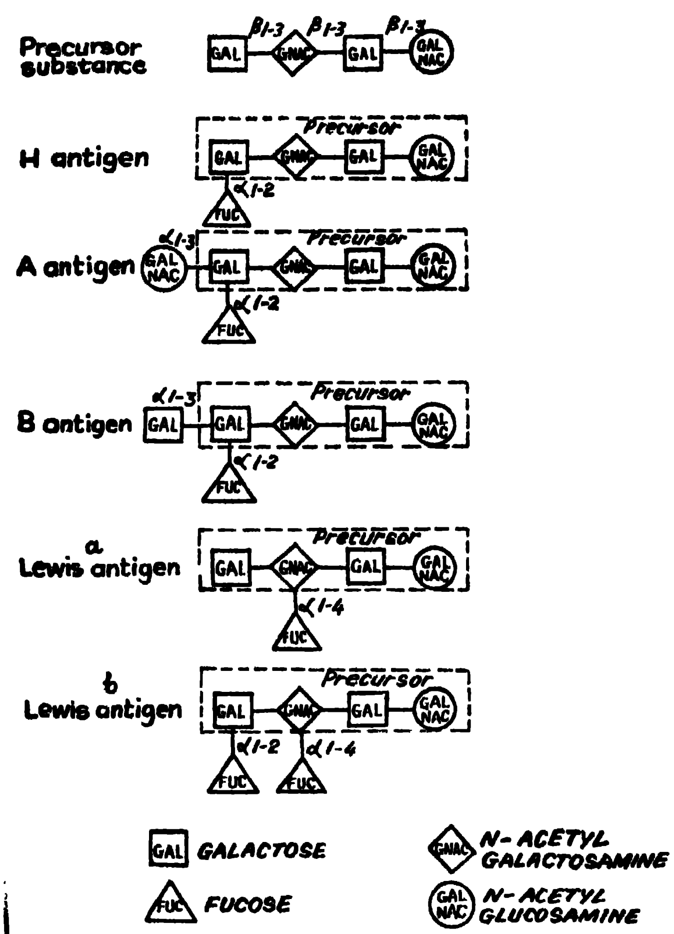


Fig. 5 Chemical structures of blood group antigens A, B, H, Le^{a} and Le^{b}. Precursor substance is common in all. Addition of a particular sugar in a particular position gives the specificity of different blood groups. Note the addition of GAL-NAC to H and GAL to H giving rise to A and B antigens. Both these antigens have H antigen also as a part of them. The Le^{b} antigen is considered as an interaction of Le^{a} and H and has the fucose units at two positions

not have normally had A or B group children. But the children do belong to these groups. Obviously, the A and B genes came from the Oh mother since the O father has both O genes.

A similar suppression of the regular genes is also known in the rare type of blood in the Rh system known as Rh$_{null}$ which lacks all Rh antigens. Complexities of other blood group systems like MNSs, Kell, Duffy, Kidd and Lutheran have revealed that these bloods lack all the possible antigens known in the particular system. In the inheritance of many such rare blood groups, termed as " minus-minus " phenotypes, a new gene is involved as in the "Bombay" group. Because blood groups have a clear pattern of inheritance and well-defined distribution, they are useful tools in genetic studies.

Though most of the blood group antigens are present on red cells, some antigens, A, B, H and Lewis, are also present in other body tissues and tissue fluids like saliva in many people. Such people are classified as secretors, while those who lack them in saliva are termed non-secretors. This phenomenon is also genetically controlled. Antigens found in tissue fluids have been very useful in elucidating the chemical structure which differentiates these antigens from each other. Though the general chemical composition of all antigens appears similar, the position of a particular sugar molecule decides the antigens to be either A, B, H, Le^{a} or Le^{b} (fig. 5).

Red cell antigens, though directly involved in transfusion reactions or the haemolytic disease of the newborn, were thought to be free from effects of other diseases. However, sometimes, one develops antibodies against one's own red cells; these auto-antibodies could lead to chronic anaemia and could be checked only by frequent blood transfusions.

Other blood characters

Like the red cell antigens, the other components of the blood have their own antigens. For example, the white cells and platelets have not only A or B antigen similar to red cells, but possess numerous other antigens too. Some of these white cell antigens are important in transplantation of body organs since they have similar antigens. In that case reaction occurs. Plasma proteins also have antigenic properties. Recently, a patient with burns developed fever reactions on plasma transfusion done after red cell compatibility tests. Antibodies to various plasma fractions are now known. Gamma globulin has 14 antigens known as the Gm groups. Similarly, antibodies against specific antigens in the α and β fractions of human globulins are also known. All these antigens in various plasma proteins are genetically controlled. In future, tests will be needed for all these factors, besides the red cells. For antibodies against many of these blood components do cause reaction. Auto-antibodies against the white cells and platelets can result in loss of the respective fractions; auto-antibodies against globulins can cause gammaglobinemia.

In the last 10 years, researchers have been trying to find out the association of certain diseases with particular blood groups. However, only two disease conditions have shown such associations with the ABO groups. Duodenal ulcer and gastric ulcer are common in O group and stomach cancer in A group individuals. Other associations, though indicated in some cases, have been contradicted by other studies.

ROUND-UP OF RESEARCH

Physiology of Vision

NEUROPHYSIOLOGISTS are beginning to understand how the nerve cells of the brain are equipped to deal with vision. It is now known that the region of the brain that deals with information from the eyes is a part of the cerebral cortex, known as the " striate cortex ", which is roughly located at the back of the head. Light striking the rods and cones — kinds of light-sensitive nerve cells — of the retina is converted into a train of nerve impulses which are transmitted down to the optic nerve and then from there to the striate cortex. In fact, studies on the electrophysiology of the visual system have led to the hypothesis that hundreds of parallel neurones (nerve cells), excited in the outer layers of the retina, converge and add up in a neuron of a higher order in the inner retina.

Dr. B. Pomeranz of the Department of Zoology, University of Toronto, Ontario, Canada, and Dr. S. H. Chung of the Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, USA, have now shown in a research report in *Science* (*170*, 983, 27 November 1970) that there is a correlation between the anatomy or the structural appearance of a nerve cell in the optic nerve and its physiology or perceptual function as extrapolated from electrophysiological data. They have conducted experiments on tadpoles and shown that the structure of the dendrites in a neuron of higher order codes for the detection of objects of different shapes.

In an earlier attempt to study the physiology of vision, scientists at the Massachusetts Institute of Technology, USA, had chosen to study the vision of frogs. To a frog, the most important things in life are the flies that it eats and the predators that eat it. Hence, the MIT scientists tested the vision of frogs using small moving dots as a reasonable approximation of a fly, and dark edges moving across a light ground as representing the approach of a possible predator. By means of micro-electrodes, they recorded the electric impulses passing along the optic nerve from the light-sensitive nerve cells in the outer retina.

The results of their experiments indicated that the individual cells in the frog's retina act only as " edge detectors " or " point detectors ", ie they send out electric impulses either only for edges or only for moving dots. It was found that an adult frog is able to respond to both edges as well as moving dots. The American scientists were also able to correlate, though not very conclusively, the shape of the objects seen by the frogs with the structural appearance of the nerve cells in the inner retina.

Drs. Pomeranz and Chung have now conducted similar experiments in the retina of tadpoles. They studied the visual detection of form by electrophysiology in 210 tadpole frogs (*Rana catesbeiana*, *R. pipiens* and *R. clamitans*) immobilised with local anaesthesia. The eyes were submerged in water so as to look out through the flat wall of a lucite chamber at a screen 25 cm away on which the moving dots and edges were projected. Electrical recordings were obtained with platinum black micro-electrodes from 1854 single axons in the optic nerve.

Their experiments have revealed that tadpoles responded to moving dots like adult frogs, but are not capable of responding to moving edges. A microscopic examination of the dendrites of neurones in the optic nerve section showed that the structure corresponding to edge detection in an adult frog was absent or underdeveloped in the tadpoles. Further, the structure of the nerve cells corresponding to moving dots was the same in the tadpole and in the adult frog. These results give strong support to the conclusion that the structures of dendrites in neurones of a higher order in the optic nerve code for visual recognition of form.

Do Viruses Cause Cancer?

ADVANCES made in molecular biology so far have established that the genetic information in ordinary cells is contained in the nucleic acid known as DNA. This information is converted to proteins necessary for the metabolism of life through another type of nucleic acid, RNA. One of the guiding principles or the central dogma in molecular biology has been that DNA can make RNA, and RNA can in turn make proteins. The first exception to this rule was discovered about 9 months ago, when it was shown that certain tumour-forming viruses, having RNA as a genetic material, have the ability to make DNA which then becomes integrated with the genetic apparatus of the cells they invade. The discovery that the central dogma can be reversed (see Science Today, p. 9, December 1970) has promised an extraordinarily rich harvest for cancer researchers. Experiments conducted during the past few months are slowly unravelling the details of the processes which occur when RNA viruses invade cells with genetic material made of DNA.

Much more exciting than any of these has been e announcement in *Nature* (*228*, 927, 5 December 970) by Dr. R. C. Gallo of the National Cancer nstitute, Bethesda, Maryland, USA, and his olleagues, Drs. S. S. Yang and R. C. Ting of the ionetics Research Laboratories, also at Bethesda, hat RNA-dependent enzymes, known as DNA olymerases, identical to those found in RNA tumour iruses, are found in the abnormal white blood ells of patients suffering from acute leukaemia but ot in cells taken from normal individuals. This nnouncement, if confirmed, will be the most ositive evidence so far that viruses play a part in ausing some types of cancer in human beings.

The first proof that viruses may be linked with ancer came as long ago as 1905, when Dr. P. Rous howed that particles resembling viruses can transmit particular kind of cancer called a sarcoma from ne chicken to another. Since then, similarly elusive irus particles have often been implicated in the ormation of particular cancers in rabbits, mice and ther species. Recently, several types of cancer iruses, having RNA as genetic material, have been olated in the laboratory, and they have been used or experimental studies to understand what happens hen cancer viruses invade normal cells. However, o far the search for human, or for that matter rimate, RNA tumour viruses has proved fruitless.

The experiments of Dr. Gallo and his colleagues ere performed under the premise that the virus articles may have only a transitory existence in the ancerous cells and may be difficult to detect by rdinary methods, whereas the detection of the resence of the enzyme which uses RNA as a model o make DNA molecules might be more rewarding, nd might also serve as a very sensitive index for ancer. The American biologists isolated abnormal hite blood cells from patients suffering from acute eukaemia. In fact, the white blood cells from three atients were compared with those from 48 persons ree from the disease. The result of their research was hat RNA-dependent DNA polymerase activity was etected in the cells of all the three patients suffering rom acute leukaemia. The activity was, however, bsent in the cells of the 48 healthy people.

The significance of the work of Dr. Gallo and his olleagues is that they have raised the hope that a ensitive assay of the RNA-dependent enzyme may rove to be a useful tool for the diagnosis of leukaemia and, perhaps, other forms of cancer. Further, t should be possible to find drugs that block the ability of RNA to make DNA, but do not interfere with he other cellular activities. If the manufacture of DNA from RNA is a characteristic only of cancer ells, these drugs should selectively attack them ithout damaging normal cells.

It now appears, however, that the momentous discovery of Dr. Gallo and his colleagues may be very shortlived, for another team from the USA led by Dr. G. J. Todaro has reported in *Nature* (*228*, 318, 29 January 1971) that normal cells of both humans and mice can make DNA from RNA. So far, this team has shown only that the activity is present in extracts prepared from the cells, so that it is not proved that a similar event happens in the living organism. Despite this, the results of Dr. Todaro's investigations indicate that the presence of an enzyme depending on RNA cannot be used to give advance warning of cancer.

These results, no doubt, will be a great setback and cause disappointment among those seeking cures for cancer. However, the idea that the central principle of molecular biology works in either direction even in normal cells is something which is scarcely understood at all at present.

Mercury Pollution

CONCENTRATIONS of organomercurial compounds as low as one part per billion can reduce the growth and photosynthesis of both marine and fresh water planktons. This is the conclusion of a study by Drs. R. C. Harris, D. B. White, and R. B. Macfarlane of the Department of Oceanography, Florida State University, USA, on the effects of four commonly used fungicides containing mercury.

Mercury pollution is at present a serious problem in many parts of the world. People are reported to have died as a result of eating fish from mercury-contaminated coastal waters of Japan, and in Scandinavia, high concentrations of mercury in fish and birds have been traced to industrial and agricultural discharges. However, a total lack of information on the biological effects of mercury has prevented the setting up of any limits for the discharge of compounds containing mercury into the sea, rivers or lakes. For the protection of humans, the USA and the USSR have tentatively adopted a standard of 5 parts per billion for mercury in drinking water.

In their experiments, reported in *Science* (*170*, 736, 13 November 1970), the American scientists evaluated the effects of fungicides containing mercury in the laboratory on planktons obtained from both sea and fresh water lakes. The planktons were first exposed to the fungicides for various periods and in varying concentrations. Five micro-curies of $NaHCO_3$ containing the radioactive isotope carbon-14 were then added to each sample. During photosynthesis the planktons take in carbon, and by exposing the samples to artificial light in a growth chamber the scientists were able to measure the rate of photosynthesis by the amount of carbon-14 taken up by the planktons. It was observed that at a concentration of 50 parts per billion of mercury all uptake of inorganic carbon was stopped and there was complete inhibition of growth. At one part per billion, there was a significant reduction in both photosynthesis and growth in marine as well as fresh water planktons.

The seriousness of these findings arises from the central role of planktons in almost all food chains of seas and lakes. Although, at present, fish seem to escape any direct injury from trace amounts of mercury, it is only a question of time before it permeates through to other links in the food chains, including fish. The results indicate that concentrations of mercury well below the limits tentatively adopted by the USA and Soviet Union, as safe for drinking water, can cause damage to planktons. Hence, Dr. Harris and his colleagues advocate a complete ban on the discharge of organic compounds containing mercury in natural waters as soon as possible. They also plead for a study of the long term effects of mercury pollution, below concentrations of one part per billion, to establish adequate water-quality standards.

K. A. Neelakantan

Superheavy Elements Tracked

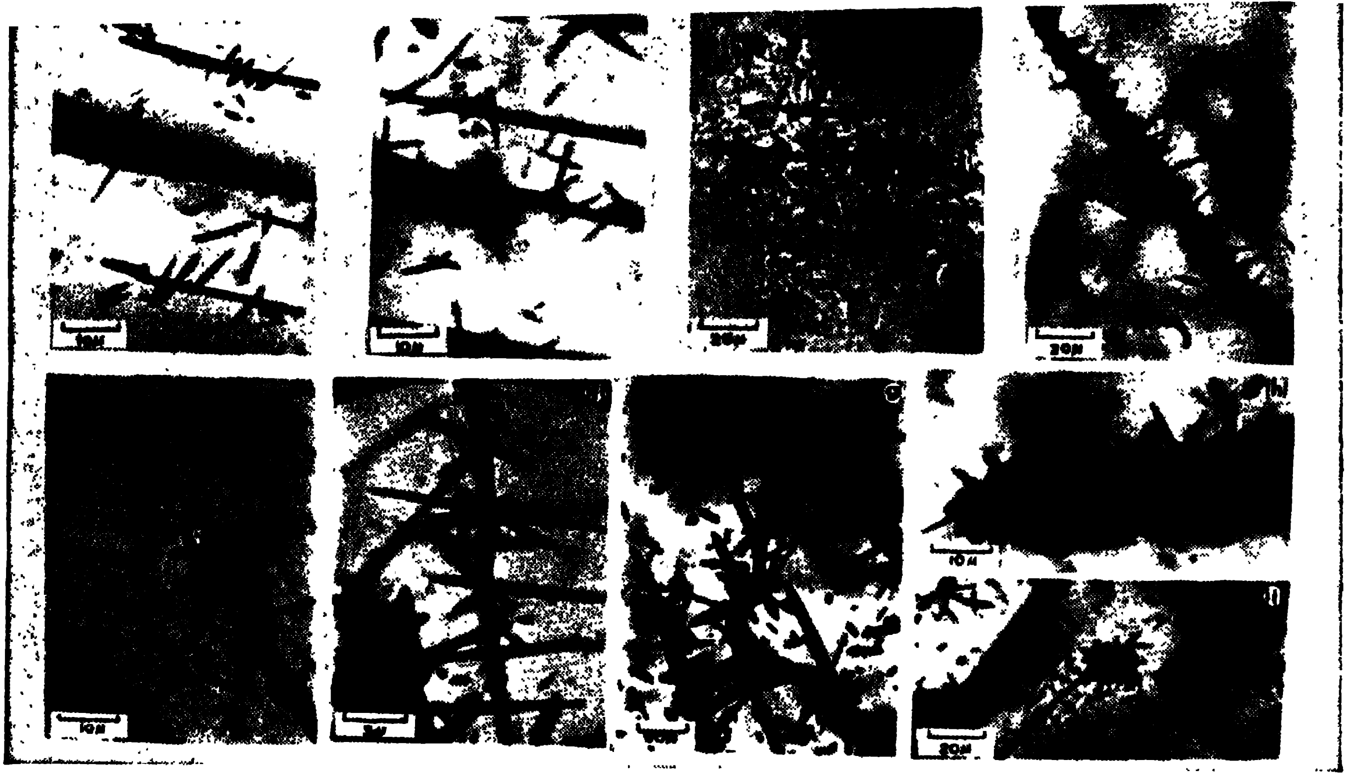
ELEMENTS tend to be increasingly unstable with increasing atomic numbers and the number of protons in their nuclei. Highly radioactive heavier elements do not occur naturally because they disintegrate rapidly. Thus while plutonium ($_{94}$ Pu ^{241}) has a half-life of 1·2 × 10 years, fermium ($_{100}$ Fm ^{256}) has a half-life of only 2·7 hours; element X with atomic number 104 will not exist for more than a fraction of a second. Some of these elements in the transuranic series such as plutonium (Pu ^{94}), americum (Am ^{95}), curium (Cu ^{96}), etc up to lawrentium (Lw ^{103}) are artificially produced in the laboratory by nuclear reactions. But theoretical calculations based on energy balances in atomic shells had predicted that stable superheavy elements can exist in the region of atomic numbers 114 to 126. Can superheavy elements exist? (See SCIENCE TODAY, January 1968). Researchers from the Tata Institute of Fundamental Research, Bombay, have now reported that they have found evidence for the presence of superheavy elements in meteorites and Moon dust; fossil track studies in these matter have shown that superheavy elements with atomic numbers above 110, were present when these matter solidified.

Heavy charged particles leave identifiable trails when they pass through common silicate minerals; these trails can be chemically enlarged and observed under a microscope. The TIFR group, Dr. N. Bhandari, Miss S. G. Bhat, Dr. G. Rajagopalan, Mr. A. S. Tamhane and Dr. V. S. Venkatavaradan, working with Prof. D. Lal, measured the lengths and distribution of such fossil tracks created by multiply charged nuclei of elements like vanadium, iron and nickel from cosmic rays and fragments from naturally disintegrating heavy elements. These were compared with laboratory-induced (using neutrons) tracks and theoretically calculated track lengths for heavy and superheavy elements. Their results include (*i*) evidence for the past existence of superheavy elements in lunar dust and meteorites; (*ii*) evidence for the presence of heavy transuranic nuclides in Moon dust. Pu^{244}, known to be present in meteorites, was also present in Moon dust (but not in rocks, as Pu^{244} had already become extinct when the rocks formed) when it last cooled; (*iii*) the Moon receives about 15 particles of energy above 1 MeV/n per square metre every second from cosmic ray nuclei in the iron group — vanadium, chromium, manganese, iron, cobalt and nickel (this result came from the study of rocks from the Apollo-12 landing site); and (*iv*) some of the rocks now exposed on the lunar surface at the Apollo-12 landing site had outcropped from depths exceeding 10 to 20 cm about 2 million years ago, and that the landing area had been subjected to heavy meteorite impacts and the consequent mixing of the lunar regolith, or " gardening ", during the last 500 × 10^{6} years.

Some doubts?

A Soviet scientist, Gurgen Ter-Akopyan, has declared, at an international conference on the physics of heavy ions held at Dubna, Moscow, that there is no evidence to prove the relationship of the unusual tracks studied by the TIFR group to superheavy elements. Firstly, he says, there is no evidence to show that traces of superheavy nuclei should be exactly of that length. Secondly, it is not unlikely that these tracks are not tracks of particles at all but cracks caused by mordant treatment or rock fragments aged several thousand years.

Scientists from the Soviet Union, the USA and the Federal Republic of Germany have been carrying on investigations to find traces of superheavy elements in Moon dust, the Earth's entrails, the ocean beds, the Antarctic snow and splinters of ancient vases and glasses from Gothic temples. They have discovered numerous traces of some ' mysterious spontaneous radiation source ' which clearly differs from uranium.



Microphotographs of fossil tracks in extraterrestrial matter (Apollo-12 lunar dust samples and some meteorites). The tracks are, in general, formed by the passage of heavy charged particles like cosmic rays or fission fragments. These tracks are chemically etched and silvered for high contrast optical viewing. Most of the tracks seen are of full length — made possible by a technique developed by the Geophysics Group headed by Prof. D. Lal of the Tata Institute of Fundamental Research — which makes it possible to detect superheavy nuclei

This chronology has been worked out by studies of lunar regolith components of millimetre and submillimetre sizes.

Using an improved version of the fossil track length technique, the researchers measured the total recordable length of fission fragments from the lengths of tracks completely confined within the mineral grain; the method used till now was to measure the partial lengths of tracks on a fractured crystal surface, interpretation of which was complicated by the presence of cosmic ray nuclei tracks. Further, based on calculations of normal track densities for cosmic ray nuclei in crystal cleavages, they identified the excess tracks due solely to fission fragments of heavy and superheavy elements. These were checked against artificial neutron-induced tracks in meteoritic and lunar crystals.

Comparison of experimentally calculated track lengths with neutron-induced and fossil tracks for U^{235}, U^{238} and Pu^{244} showed that the measured lengths of induced and fossil tracks were 3 to 4 microns shorter than theoretical lengths. Allowing for deviations of 1 to 2 microns, the number of tracks on study reached a peak at the corresponding fossil track length for each of these elements. This meant that about 2 microns are not recorded for each of these elements towards the end of its fission range where the rate of fission falls below the critical point above which only tracks are etchable. In that case, the measured track lengths due to the fission of superheavy elements would similarly be 2 microns shorter than the theoretical lengths. The theoretical track lengths for superheavy elements in the group Z-114 to 126 (Z representing atomic number) were 20 to 26 microns for different study samples; the mean recorded lengths in fossils were 17 to 24 microns. In the meteorite Angra dos Reis, which does not need correction for cosmic ray track records, seven tracks over 18 microns and two of 21·6 and 25·8 microns each were measured.

Of the 1,600 tracks studied, 933 were longer than 13 microns; below this value the tracks are solely due to cosmic ray nuclei. Of these again, 694 were excess tracks, ie tracks due to fission fragments, with a consistent increase in all samples in the number of such tracks in the region 13 to 16 microns (356 tracks) and 16 to 22 (338 tracks) microns, corresponding respectively to Pu^{244}, U^{238}, etc and superheavy elements around the atomic number 114.

K. P. N.

POSTER DESIGNED BY AMERICAN MUSEUM OF NATURAL HISTORY

ADDICTIVE DRUGS

AJOY GUPTA

DRUGS! Spell the letters and you spell the coat-of-arms of the new generation. They, of course, have their own endearing terms: Heroin, LSD, Mary Jane, purple hearts and a host of others. Today their misuse is so widespread that they have become nightmares for both the sociologists and the law enforcement authorities in almost every country. These 'drugs' were discovered in the course of man's search for panacea; somewhere along the way, man also discovered the ambrosial short-cut to delight.

The word 'drug' here does not mean medicines. It includes only those chemical substances which have a psychic effect, like altering the mood, perception or consciousness. As a corollary, it also means the harmful agents, the addictives.

This is where the problem lies. Because they are ambrosials, drugs bring delight — some through sedation, others through stirring of the senses. And then, the taker wants them again, and again, and again. Addiction begins. 'Addiction', 'dependence'— they mean more or less the same things. Then comes 'tolerance' — just repeated doses will not do; the addict needs larger and larger doses to get the same kick.

It was only very recently that a standard pharmacology of these addictive drugs was established. Although research is still going on, we can describe the nature and effects of the 'drugs' in general terms. There are mainly four different types of drugs which are commonly used today:

(*a*) Amphetamines and barbiturates, commonly known as 'Pep Pills' or 'Up' and 'Down' pills.

(*b*) Marijuana. It is also known by various other names in different countries, like Cannabis, Indian Hemp, Pot, Hashish, Charas, Bhang, Ganja, Dagga, etc.

(*c*) Hallucinogens or psychedelic drugs. The commonly used drugs in this group are Mescaline, Psilocybin, LSD (Lysergic acid diethylamide), DMT (dimethyltryptamine), etc.

(*d*) Narcotic analgesics of the opium group, like Morphine, Codeine and Heroin, etc.

In Table I, the effects of some common drugs are given for comparison.

Amphetamines

We can start with amphetamines. These are synthetic drugs of the sympathomimetic amine group, structurally similar to adrenaline. In medical practice, they are used to treat obesity, mild depression, narcolepsy (a tendency to fall asleep at any time), and certain behavioural disorders in children. The ordinary therapeutic dose is 10 to 30 mg per

TABLE 1

Name	Craving or physical hunger	Pronounced psychic effects on administration	Psychic dependence	Physical dependence	Tolerence	Psychotoxic on withdrawal
Barbiturates	√	√	√	√	√	√
Amphetamines	√	√	√	—	√	—
Alcohol	√	√	√	√	√	√
Marijuana	—	√	√	—	—	—
LSD	—	√	√	—	—	—
Heroin and Morphine	√	—	√	√	√	√
Nicotine	√	—	√	—	—	—

The above table is interesting in that it explodes certain popularly held notions. First, both marijuana and LSD do not produce any physical craving or physical dependence: they have only psychic effects. Second, morphine, heroin and nicotine are the only drugs which do not produce any major psychic effects. Lastly, judging impartially, alcohol seems to be the most harmful one, even more harmful than heroin, because its prolonged use in itself causes physical and nervous deterioration

day; the effect is a feeling of well-being and increased alertness. Amphetamines are indeed 'superman' drugs. They act on the central nervous system, and give a tremendous boost to self-confidence and energy while increasing endurance.

There are various brands of amphetamines; most are illicitly available. The common names are: Benzedrine (bennies), Dexedrine (dexy), Methedrine (meths), Durophet (black bombers), etc. There is another group of drugs which combines amphetamines with barbiturates; the effect is stronger than either drug can produce individually, although the mechanism of this supra-active effect is not clear yet. These are commonly known as "purple hearts" and "French blues" (the clinical name is Drinamyl).

Amphetamine abuses can be classified into three distinct patterns. To begin with, there is a relatively minor form of abuse by people who need a temporary lift of physical and mental mood. The group usually includes teenagers and students cramming for examinations and exhausted housewives and overtired businessmen. Then there are people who, besides needing energy, are also sadly bored and understimulated. To them, the drug brings the kicks. Another interesting effect of this drug is that it decreases inhibition and the user can adapt to a different set of behaviour and morals. The third category covers people who become easily susceptible, people who need temporary boosts to their endurance, like athletes, heavy manual workers and long-distance truck drivers who have to go without sleep for long stretches.

Over the past few years amphetamines have been increasingly used intravenously. The injections are known as "speed" or "splash". Over and above a marked euphoria, the user experiences a sense of enhanced physical strength and mental capacity, and feels little need for either sleep or food. Difficult to substantiate by objective means, there is also the claim that the drug makes sex more pleasurable by permitting delayed orgasms in both the male and the female.

The high kicks soon boomerang. The increase in stimulus is always on borrowed time. The extra energy comes as a forced loan from the body's resources; after the immediate lift lasting a few hours, comes exhaustion and depression. Ultimately, the overdraft against physical reserves starts taking its toll.

Barbiturates

If amphetamines stimulate, barbiturates sedate. These are synthetic hypnotics and are major ingredients in sleeping pills and are also used as anaesthetics in medical practice. Phenobarbital, one of the earliest barbiturates to be synthesised, has distinctive anticonvulsant properties useful in the treatment of epilepsy. The addiction to these drugs causes one of the worst forms of suffering, because it leads to craving or both psychic and physical dependence. Barbiturate poisoning is also responsible for a large number of deaths. Barbiturates are derivatives of barbituric acid, first synthesised more than 100 years ago by a German chemist, Adolph Von Bayer, by condensing urea with malonic acid. Since then thousands of different barbiturates have been synthesised, out of which hardly half a dozen seem to suffice for current medical needs.

The incidence of compulsive abuse of barbiturates cannot be stated with accuracy, but it probably exceeds that of opioids. Illegal traffic in these drugs is common, and they are known in the drug users' jargon as " goof balls " or " downs ". The short-acting barbiturates such as pentobarbital (" yellow jacks ") or secobarbital (" red devil ") are generally preferred to long-acting ones such as phenobarbital. Opioid users frequently take barbiturates to boost the effect of weak heroin, and many heroin addicts are physically dependent on both heroin and hypnotics. Sometimes, they are used as a substitute when heroin is in short supply.

Both the acute and the chronic effects of barbiturate intoxication resemble those of alcohol. The intoxicated individual shows a general sluggishness, difficulty in thinking, slowness of speech and comprehension, poor memory, emotional liability, irritability, moroseness and suicidal tendencies, etc. The original introduction to the drug in many cases comes through the physician's prescription which gradually develops into tolerance and physical dependence. And despite the tolerance, the lethal dose remains essentially constant. As tolerance increases, the margin of safety decreases and accidental poisoning occurs when it reaches the limit of the lethal dose.

Marijuana

Marijuana, or whatever name you might call it, is supposed to be the most widely used drug today. There have been many popular misconceptions about its origin, nomenclature, uses and effects. For the last few years, the National Institute of Mental Health and the Bureau of Narcotics and Dangerous Drugs of the USA have been doing a lot of systematic research on this drug and their findings have clarified many of the facts and fictions attributed to this drug.

Cannabis, obtained from the flowering tops of hemp plants, is a very ancient drug. Other names for cannabis or its products include hashish, charas, bhang, ganja, dagga and marijuana. The common hemp is a herbaceous annual, of which *Cannabis sativa* is the sole species and *Cannabis indica* and *americana* some of the few varieties. The resinous exudate of the tops of the female plant contains most of the active ingredients. In the Middle East and North Africa, the resin is called hashish; in the Far East it is called charas. The dried leaves and flowering shoots of the female hemp plant, containing smaller amounts of the active substance, are called bhang, and the resinous mass from the small leaves and brackets of inflorescence is called ganja. In the United States, the term marijuana is used to refer to any part of the plant or extract therefrom which induces somatic and psychic changes in man. Most commonly, the plant is cut, dried, chopped, and incorporated into cigarettes.

The US Bureau of Narcotics, in a recent publication (*National Clearing House for Mental Health Information Bulletin No. 5021*), has clearly stated certain facts about marijuana for the public's guidance:

(*a*) Marijuana does not cause physical addiction, since tolerance to its effects and symptoms on sudden withdrawal do not occur. It can, however, produce habituation (psychological dependence). (*b*) Marijuana is not a narcotic except by statute. (*c*) Marijuana has no aphrodisiac properties, as is popularly believed in some societies. (*d*) Marijuana does not lead to violence. People under its influence tend to be passive. Of course the personality of the user is as important as the type of drug used in determining

whether chemical substances lead to criminal or violent behaviour. (*e*) Marijuana is not altogether harmless in the long run. Instances of acute panic, depression and psychotic states are known, although they are infrequent. (*f*) Marijuana might bring fantasies of enhanced creativity but they are illusory, as are the " instance insights " reported by marijuana users. (*g*) It is not known whether occasional use of marijuana is less harmful than occasional use of alcohol. Researches on the effects of various amounts of drugs for various periods is now being carried out.

In the United States and other Western countries, marijuana (also known as " tea ", " Mary Jane ", " grass ", " pot ", " weed " or " reefer ") is usually taken by rolling it into cigarettes and inhaling the smoke. It is also taken with drinks or incorporated in foods like sweets, cakes, etc. When the drug is taken by inhalation of its smoke, effects occur within a few minutes and the duration of effect is relatively short. With the oral ingestion of larger dosage, the duration of the effects become more prolonged. The physical effects are mainly increase in pulse rate, dryness of the mouth and throat, dizziness and nausea, etc. A marked increase in appetite (especially for sweets) is said to be characteristic. No significant change occurs in blood sugar, respiratory rate, blood pressure or size of the pupil.

The subjective effects of marijuana are largely dependent not only on the personality of the user but also on the dose, the rate of administration and the specific circumstances in which the drug is used. The most common reaction is the development of a dreamy state of altered consciousness in which ideas seem disconnected, uncontrollable, and freely flowing. Ideas come in disrupted sequences, things long forgotten are remembered while other well-remembered things cannot be recalled. Perception is disturbed, minutes seem to be hours and seconds seem to be minutes. Space may be broadened, and near objects may appear far away. There are often marked alterations of mood; most characteristically there is a feeling of well-being. Uncontrollable laughter and hilarity to minimal stimuli are common. Similarly, the subject may go into moody depressed reaction without any reason.

Marijuana as a drug is known to be in use since the beginning of history, but over the past decade or so there have been explosive increase in its use throughout the whole world, specially in the affluent societies. The reasons are not very clear but many observers feel that it is related to a change in the values of young adults. Conflict with the values of the establishment prompts many into looking for a temporary escape, and marijuana is perhaps the cheapest and most easily available aid.

Despite the increasing popularity of marijuana, relatively little was known till very recently about the chemistry and pharmacological action of this drug. The psychotomimetic or mind-bending properties of marijuana are probably caused by two isomeric tetrahydro cannabinols (THC). This was first suggested by Dr. Roger Adams in the USA and Lord Alexander Todd in Britain in 1940. Both of these isomers were isolated from the resin extracted from the plant. The potency of the effect apparently depends on the concentration of THC present in the drug. In 1964, Dr. Raphael Mechonlam of Jerusalem University, Israel, first worked out the structure of this compound. Since then it has been synthesised and a lot of research work is being conducted now on the chemistry, pharmacology and standardisation of assay methods for detection of THC in various laboratories of the world.

Hallucinogens

Of all the drugs popularly abused today, probably none are viewed with more alarm by the general public than the hallucinogens and narcotics. Hallucinogens are drugs that stimulate sensory perception having no basis in physical reality. Hallucinations may be visual, auditory, gustatory (taste), olfactory (smell), or tactile (touch). However, more often than not, hallucinogenic drugs are taken for their visual effects. Some of the more commonly abused hallucinogens are mescaline, psilocybin, LSD and DMT. The first two are obtained from natural sources and the others are mainly synthetic.

The interest of the scientific world in the hallucinogens has been intimately bound with their use to

produce experimental psychoses. Mescaline, the first hallucinogen to be studied in this context, is found in the peyote cactus (*Lophophora williamsii*) and has been known to Mexican Indians even before the discovery of America. Havelock Ellis in 1890 showed great interest in the subjective effects of mescaline, which induced further research in the hallucinogenic potentials of this drug. The active principle of peyote, the alkaloid mescaline, was isolated in 1896, but the structure of mescaline, which is 3, 4, 5 trimethoxy phenylethylamine, was determined by Spaeth only in 1918. The drug was named after the American Indian tribe of Mescalero Apaches who used it in their religious rites.

Psilocybin is the active principle of another Mexican plant, the sacred mushroom *Psilocybe mexicana* with similar properties. This was brought to the attention of the Western world in 1953.

LSD is lysergic acid diethylamide. This was synthesised in 1938 by Hoffmann in the Sandoz laboratories at Basle, Switzerland. Its psychic properties were noticed much later in 1943, when he accidentally sniffed a few micrograms of it. It is active in very small doses and is 100 times more potent than psilocybin and 7,000 times that of mescaline. DMT (N, N-dimethyltryptamine) is also a similar synthetic product but not active orally; it is only active when smoked or injected.

There is no sharp line that divides the psychedelic from other classes of centrally active drugs. Most descriptions of the "psychedelic state" include several major effects. There is heightened awareness of sensory input, often accompanied by an enhanced sense of clarity, but a diminished control over what is experienced. Frequently there is a feeling that one part of the self seems to be a passive observer (a "spectator ego") rather than an active organising and directing force, while another part of the self participates and receives the vivid and unusual sensory experiences. The environment may be perceived as novel, often beautiful and harmonious. The attention of the user is turned inward, pre-empted by the seeming clarity and portentous quality of his own thinking processes. In this state the slightest sensation may take on a profound meaning. Indeed "meaningfulness" seems more important than what is meant, and the "sense of truth" more significant than what is true. Commonly, there is a diminished capacity to differentiate the boundaries of one object from another and of the self from the environment. Associated with the loss of boundaries there may be a sense of union with "mankind" or the "cosmos". To the extent that these drugs reveal this innate capacity of the mind to see more than it can tell and to experience and believe more than it can explain, the term mind expanding is not entirely inappropriate.

There are volumes of literature available on the descriptions of the hallucinogenic and psychedelic effects of these drugs which is beyond the scope of this article. Physiological effects of these drugs are not very toxic and no permanent physical damage or death has been reported. Some authors have reported the possibility of chromosome damage in human beings but it has not been confirmed. Physical dependence on the hallucinogens does not develop Tolerance to LSD develops rapidly and a long time is needed to re-establish response in a tolerant individual.

In the United States the use of LSD and related psychedelics reached a peak in 1966–67; thereafter, it gradually declined. Today, the drug is more used by college students and the affluent and the artistic types than by the poor or the sociopathics.

Opioids

Narcotic analgesics or opioids include the naturally occurring opium alkaloids, semisynthetics, and number of synthetic compounds with morphine-like activity that may or may not be structurally similar to opium alkaloids. The term narcotic analgesic commonly includes the compounds like morphine, heroin (diacetyl morphine), codeine (methyl morphine), methadone (6-dimethylamine-4, 4-diphenyl -3heptanone).

Like many of the hallucinogens, narcotic analgesics were first isolated from plant material. The major narcotics are derived from the opium poppy, *Papaver somniferum*, found in various parts of Asia. The dried juice from the unripened seed pod of this plant is opium — a mixture of several alkaloids. Morphine — a major constituent of opium powder — was isolated in 1805, followed in the next 50 years by codeine and papaverine. Heroin, a semisynthetic morphine derivative, was first produced in 1874. Since then, a variety of synthetic drugs with opium-like activity (methadone, meperidine, and others) have been prepared and have found widespread application.

The opioids are unsurpassed in their ability to relieve moderate or severe pain. Unfortunately, pharmacologists have been unable to divorce addiction potential from the analgesic properties of these drugs. Although much research continues to be directed towards finding a strong analgesic without the attendant addiction liability of the opioids, morphine remains the standard against which other strong analgesics are measured.

Heroin is several times more potent than morphine though it is not considered medically useful in the USA. When it was first developed, heroin was not known to be addictive, but it has since become the drug of choice among chronic opiate abusers in the lay population. Clinical addicts, on the other hand, seem to prefer morphine or synthetics like meperidine.

The physiological effects of opioids in therapeutic doses are not particularly remarkable. Respiration and cardiovascular activity are somewhat depressed, the pupil is constricted, and body temperature may be elevated. Gastrointestinal disturbances are frequently reported. Nausea or vomiting may occur and decreased intestinal motility may cause constipation. In higher doses, respiration may be severely depressed. Toxic effects of overdose are coma, shock, and respiratory failure leading to death.

The development of tolerance and physical dependence with repeated use is a characteristic feature of all the opioid drugs, and the possibility of developing psychological dependence on the effect of these drugs is one of the major limitations of their clinical use. Physical dependence is related to dose and frequency of use. At higher chronic doses, a full-blown abstinence syndrome develops upon withdrawal, including severe and painful physiological responses. Addiction to heroin is perhaps the worst type of addiction because it produces craving as well as physiological and psychological dependence, tolerance and toxic withdrawal symptoms. Contrary to popular misconception, chronic opioid addiction in itself is not incompatible with the normal life of an individual, because it does not cause any direct physical damage. But such cases of moderate users are very rare. There is another incorrect popular belief persisting in many countries since the middle ages that, opium can be used as a sex tonic. It is now definitely known that opium has no aphrodisiac properties.

Alcohol

Compared to all the different drugs we have discussed so far, alcohol can get the highest ranking in terms of harmful effects. And yet, it has the unique distinction of being the only potent drug (i.e. pharmacologically active agent) whose self-induced intoxication is socially acceptable. In fact, alcoholism is a more significant problem than all the other forms of drug abuse put together. In the USA alone, it has been estimated that about 5 million people exhibit some form of alcoholism, and about 5 per cent of these eventually reach the derelict stage. A total of 750 million dollars is lost every year in potential wages, crimes, accidents and medical and custodian care. The cost of broken homes, loss to society, and human misery is beyond any calculation.

Alcohol has a marked effect on the central nervous system. The question whether it is a "stimulant" has long been debated; today it is firmly believed that it is not. Rather it is a primary and continuous CNS depressant. The apparent stimulation of alcohol results from the unrestrained activity of various parts of the brain that are freed from inhibition as a result of the depression of inhibitory control mechanisms. Electro-physiological studies suggest that alcohol first exerts its depressant action upon the reticular activating system which is responsible for much of the integration of activity in the various portions of the nervous system. The result is the disorganisation of thought processes and dislocation of motor processes. Carefully performed experiments have shown that, in general, alcohol increases neither mental nor physical abilities. Although the individual often firmly believes that his performance is greatly improved, psychometric tests show the contrary results. The popular notion that alcohol is aphrodisiac is another misconception. The aggressive sexual behaviour often seen after drinking alcohol is usually a result of loss of inhibition and mental restraint.

The psychic effects become predominant only in the case of chronic alcoholics. These are people with serious personality maladjustments. They are emotionally dependent, insecure, oversensitive and suffer from marked feelings of inferiority. The causes of alcoholism are similar to those producing neurosis even in non-alcoholics. The stress and strain of modern society prepares the ground.

Addiction to alcohol, like barbiturates, has many bad effects. It develops a quick and high degree of tolerance, it creates both physical and psychological dependence and, in the long run, causes permanent injuries to many of the vital organs of the body. The spectrum is so wide that it is difficult to formulate a simple definition of alcoholism. However, for medical purposes three broad terms are generally used: (a) Acute alcoholism — acute intoxication; a temporary mental disturbance along with muscular non-coordination; (b) Dipsomania — spree drinking; periodic urges to heavy drinking; (c) Chronic alcoholism — the pathologic results of the habitual use of alcohol in toxic dosages.

A number of special problems are associated with chronic alcoholism that are not seen with other types of drug abuse. These are nutritional deficiencies like peripheral polyneuropathies, pellagra, nutritional edema, etc. These are caused by the capacity of alcohol to supply calories and depress appetite without supplying essential vitamins and amino acids.

The main syndromes of chronic alcoholism are vitamin deficiency, gastric and intestinal troubles and liver disfunction leading to cirrhosis of the lever. The nervous system also gets damaged leading to tremors of hands and tongue. Trachycardia is frequent. Mental aberrations are also common, for instance, disintegration of personality, " Korsakoff's Psychosis ", Delirium Tremens and acute Hallucinosis.

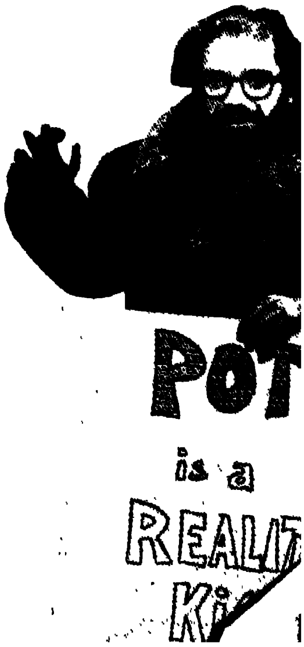
Tobacco

The ill effects of cigarette smoking leading to lung cancer has been publicised quite frequently. Tobacco is the dried leaf of *Nicotina tabacum*, a plant indigenous to America, but now grown in many parts of the world.

Tobacco is used for smoking, chewing or snuffing by millions of people throughout the world. Nicotine is the main alkaloid content in tobacco, the percentage of which varies considerably, ranging from 0·5 per cent to 8·0 per cent. Cigarette tobacco contains about 1·5 per cent nicotine. The smoke of an average cigarette may yield about 6 to 8 mg of nicotine, while the nicotine content of a 10 gm cigar may range from 15 to 40 mg. Some of the alkaloids present in the tobacco are burned, but an appreciable quantity manages to get into the respiratory tract. Approximately, 90 per cent of the nicotine is absorbed when the smoke is inhaled, compared to 25 to 50 per cent absorption when the smoke is drawn in the mouth and expelled.

Till now, nearly 500 different compounds have been isolated from tobacco smoke. In addition to nicotine, tobacco contains pyridine and other bases, isoprenoids, volatile acids, tarry and phenolic substances, furfural and acroline in varying quantities. These compounds contribute to the irritation of the mucous membrane. Nicotine has no therapeutic application. It is primarily a ganglionic stimulating agent. It markedly stimulates the central nervous system and produces tremors in appropriate dosages.

Prolonged use of tobacco may give rise to a lot of health hazards some of which may become fatal. Bronchial and paryngeal irritation may occur both due to the irritation of the nicotine and other compounds as well as due to the heat produced. In epidemiological studies, a positive correlation was observed between the incidence of lung cancer and cigarette smoking (*United States Public Health Service Report* 1964, 1967). These studies have shown that approximately 11 cigarette smokers die from cancer of lung for each nonsmoker who dies from the same cause. Considerable attention has recently been focussed on the effect of tobacco smoking on cardiovascular systems. The incidence of cardiovascular disorders and coronary heart diseases are more common in heavy smokers than in abstainers.



Progress in understanding the process of reproduction is being matched by increasing comprehension of reproductive disorders.

It has become clear that sexual inadequacy, personality disturbances and the abuse of drugs are closely linked together, particularly among males. Drugs can have significant detrimental effects on sexual capability, in the case of males, and on the infant in the womb, in the case of females.

With the expanding knowledge in this field, together with evidence that natural 'errors of the body' are at the root of many sexual problems, important questions of ethics and of law demand examination.

Sex drugs & Ethics

THADDEUS MANN

[From *Impact of Science on Society*, Volume XX, No. 4 (1970). Reproduced with the permission of UNESCO.]

IT is probably a perfectly natural tendency in the so-called civilised mankind to view sex with mixed and confused feelings. On the one hand we have curiosity, desire, imagination and an innate sense of procreative potency; at the same time, however, when we probe more deeply we encounter apprehension, inhibitions and even abhorrence, particularly in the face of deviations from what are considered to be normal sex instincts, of obstetric failures or of reproductive disorders.

Humanists and scientists alike have for some time been trying to bridge the gap which stretches between biological facts and moral issues relating to man's reproductive activities — as yet, however, without too much success. How difficult it is to close this gap is well shown by the recent developments related to the use of the oral contraceptive pill intended as a means of global fertility control. No sooner have certain hormonal formulations established themselves as reliable antifertility agents for women, than doubts have begun to assail the public as well as the scientific minds: Is the pill really the right instrument for suppressing overpopulation? Does it represent the ultimate stage in woman's sexual emancipation? Is it conducive to marital harmony? Or is it merely an aid to the *joie de vivre* among unmarried couples? And so unending debates go on, spilling over to the mass media, the outpourings and comments of which — while occasionally amusing to the expert — doubtless cause much worry and anguish to members of the lay public by undermining their faith in contraceptive techniques.

Even more complex and perplexing than man's present-day attitude to the use of contraceptives are the ways in which he tends to view reproductive failure, particularly when it ends in foetal disorganisation and the birth of grossly and overtly malformed offspring, as has happened in the recent thalidomide disasters.

Thalidomide

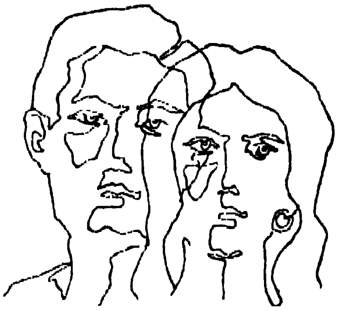
When in 1961 the first reports on the teratogenic (monster-forming) properties of thalidomide appeared in the medical press, they were received with incredulity and scepticism. This perhaps was not surprising because up till then an immense advertising campaign had represented this drug as an absolutely safe sedative. However, it soon became clear that in the human species thalidomide is a teratogen more potent than anything else previously encountered, and that if ingested by mothers early in pregnancy it predisposes some — but apparently not all — of them to a definite hazard of bearing a malformed infant. In spite of the serious and well-founded objections to thalidomide medication raised relatively soon after its introduction, the drug had continued to be freely marketed, causing much havoc. The ethical repercussions of this tragic affair have by no means subsided, and at the time of writing the manufacturers of thalidomide are still on trial.

What is almost equally sad is that the teratogenic effects of thalidomide exerted by the maternal route remain a riddle, in spite of a tremendous scientific effort to explain them and thereby to insure perhaps against a repetition of such a reproductive disaster in the future; regrettably the mode of action of maternally transmitted thalidomide still remains unknown.

Similarly, it is undecided whether or not the drug is capable of causing detrimental effects in offspring by the paternal route, an important point since this sedative was used just as extensively by men as by women. In the rabbit, at any rate, it appears that following prolonged ingestion of thalidomide by the male animals, there is a distinct adverse influence on the progeny of females that had been mated to these drug-treated bucks. This is perhaps not entirely surprising since it has been subsequently demonstrated that thalidomide fed to male rabbits readily penetrates into their semen, where it remains firmly bound to the sperm cells for several days. Moreover, it also became known later that remnants of spermatozoa are still detectable inside rabbit embryos at a fairly advanced and, therefore, drug-sensitive stage of development, so that the possibility of thalidomide being passed on to the foetus via the father is further strengthened by these observations.

Without denying the grave scientific and ethical impacts of these tragic events, we must nevertheless acknowledge as a positive gain the fact that, but for them, the medical profession, the biologists, the legislators and the public at large would never have become effectively convinced of the dangers to the unborn inherent in the indiscriminate use of drugs.

The resulting change in attitude has been astounding. Nowadays, unlike say ten years ago, no reputable pharmaceutical firm would dare recommend for general use any drug before subjecting it to exhaustive tests to ensure, amongst other things, harmlessness in reproductive performance. Hormonal preparations find themselves in a delicate situation in this respect because though they have largely been cleared from suspicion of teratogenic potency, there still remains the risk of upsets of hormonal balance not only in the mother but in the foetus as well, in the latter case giving the infant characteristics of the opposite sex. Thus, certain progestational agents given to the mother during pregnancy, for example to control habitual abortion, can induce pronounced masculinising effects in the female foetus and this has in fact happened, fortunately only in isolated cases. In the male foetus feminisation can be experimentally induced in animals following maternal treatment with anti-androgenic compounds such as cyproterone acetate, for example. In man, cyproterone acetate causes loss of libido and for this reason it has been used in the treatment of sexual deviations, including hypersexuality.



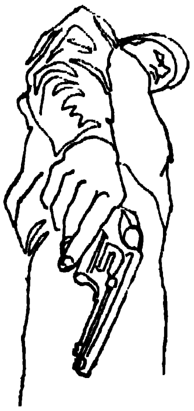
Intersexuality

Intersexuality is a condition that can arise from stimulation by hormones or occur naturally due to ' sex errors ' of the body. In either case, it poses particularly awkward ethical problems in the counselling of the afflicted individuals. Let us consider briefly two common intersex states in man, the Klincfelter syndrome and the testicular feminisation syndrome. How is one to advise people with these syndromes in respect of their education, legal status and place in society? Which of the current criteria of sex is one to apply to them: genetic, gonadal, hormonal, phenotypic, behavioural?

An individual with Klinefelter's syndrome (seminiferous tubule dysgenesis) is phenotypically male: he looks like a male and his behaviour is that of a male. But genetically he is not a male, since in his body cells he carries the XXY-chromosome complex (two X-chromosomes being characteristics of the female). The gonad on the other hand has the appearance of a testis which, though small and abnormal, is capable of producing some male sex hormone (testosterone). Notwithstanding the presence of a male-type gonad the patient is infertile.

In the testicular feminisation syndrome (androgen insenstitivity), the person has often the appearance of an attractive woman and the behaviour is ostensibly feminine. The genetic make-up however is male, as the XY-chromosome pair characteristic of males is present in the somatic cells and the Barr bodies are absent. The gonad is a testis but abnormally localised — eg inguinally instead of scrotally — and some male sex hormone is produced.

No wonder that such intersex individuals suffer because of uncertainty about their status. Occasionally, though, the life histories of the more resourceful among them achieve much notoriety in the popular press — and possibly the not inconsiderable financial gains which result make up for their distress.



The case of 'Supermales'

Just as complex and vexatious as intersex are some of the states defined as oversex. There exist some men whose cells exhibit an extra male sex chromosome, the Y-chromosome; they are the so-called XYY males, or supermales. Such individuals are born with a frequency of about 0·1 per cent of all male infants. Their existence was first spotted in the United States in 1961, and in the United Kingdom interest was aroused after a survey carried out at a Scottish maximum-security hospital revealed that not just 0·1 per cent but 3 per cent of the inmates there were XYY males. Most of them were marked by excessive height and many had a history of psychopathic behaviour, crime and sex violence.

It could be argued that such individuals deserve leniency from the criminal courts on the grounds of diminished responsibility due to chromosomal abnormality. Yet it is certain that by no means all XYY males are predestined to a life of crime; indeed, many have been described as valuable members of the community, quite free of criminal tendencies. It would seem, therefore, that some courts at any rate will continue to assess criminal responsibility in the future, as in the past, on the evidence of a man's state of mind rather than on his chromosomes. Such an approach had been adopted in a British murder trial of a known XYY male in 1968, where the defendant pleaded guilty to manslaughter of his four children, and his plea of diminished responsibility was accepted solely on the grounds of his mental abnormality. No reference whatsoever was made in court to his abnormal genetic make-up.

Amongst the many related complex situations that may arise is the problem of prospective adoptive parents who may insist on a clarification of a child's chromosomal status. Should they be told?

The legal situation may vary in different cases and in different countries, but it is certain that, as more knowledge becomes available, judges and sex-educators alike will have to face these awkward problems arising from sex-chromosome abnormalities and act accordingly.

What can we make in terms of ethics of the nature of another large group of sexual deviants, the homosexuals? While the ethical aspects of homosexuality remain in a state of flux, scientifically we are beginning to gain some insight into this situation, though so far this is limited to animal experimentation. For example, the normal sex drive of the male rat is determined by the organisation of the dominant mating centre in the hypothalamus during an early critical phase of foetal development when it becomes male-oriented under the influence of the male sex hormone, testosterone. Yet, if a newborn male rat is castrated very soon after birth and subsequently receives an implant of testosterone directly into its hypothalamus, this inherently male animal will (paradoxically) exhibit typically female sex behaviour.

Conceivably the time may come when the law-makers will inquire into the state of the human hypothalamus before pronouncing a person homosexual. Just now there is intense activity in the field of behavioural studies and answers to the many questions briefly outlined above may hopefully come from conjoint studies in reproductive physiology and psychology.

Drug dependence and sexual inadequacy

Intersexuality, hypersexuality, homosexuality, in fact many other aberrations in reproductive patterns and sexual behaviour, are also related in an as yet poorly understood manner to the problem of drug abuse, dependence and addiction. Thus, drug dependence in a man is often traceable to his incompetence in coping with the opposite sex, to his unbalanced desire which stems from low-grade capability, and an expectation that some drug or other will rid him of his sexual inhibitions. Suspicion of impotence and sexual inadequacy, real or imaginary, often constitutes an important motive in pushing a man into the ranks of drug abusers.

There are certain drugs, such as opium for instance, whose use in this respect has almost become sanctified by age-old habits. Both the older as well as the recent literature abound in references to crude opium as an aphrodisiac. Mohammedan physicians of the Moghul era are said to have been very keen on prescribing opium, not just to achieve in the patient 'stupefaction of the brain' but also to enhance the 'seminal powers' and thereby lengthen the duration of seminal discharge during coitus.

Even now apparently, in China and India, opium is regarded by many as a mild aphrodisiac. According to Sir Ram Nath Chopra, a distinguished authority in pharmacology, especially of the indigenous Indian drugs and their abuse, the use of opium as a sex stimulant is based on the belief that it is helpful in sexual impotence, especially in young men. He says: "The drug has been frequently recommended by the practitioners of indigenous medicine in the treatment of sexual neurasthenia, premature ejaculations and spermatorrhea, due to hyper-excitability of the sexual emotions. It was not uncommon among certain classes of the lower strata of society to take a small dose of opium before the sexual act. It is possible that on account of its general depressant effect on the nervous system, opium may prolong the sexual act and thus prevent premature ejaculation. This may be the reason for the aphrodisiac effects attributed to it."

But like so much in life that, pleasant at first, turns later into a nightmare; the honeymoon period — as some poets have called the enjoyable phase of opium effect — is almost inevitably succeeded in the addict not only by mental injury but also by an effect on the act of sex directly opposed to the one originally intended, namely a decrease in libido, sexual performance and fecundity.

Next to opium, historically, hemp and its derivatives rank highest as drugs which combine euphoriant and hallucinogenic properties. They go under a variety of popular names, such as hash, pot, kif, cannabis, marijuana, etc. Medical authorities in Egypt who have analysed drug addiction consider that hemp (or hashish) is often taken by men who wish to maintain, increase or regenerate their sexual powers. In Brazil, too, the use of maconha (*Cannabis sativa*) is ascribed to its reputed ability to induce erotic dreams, increase sexual prowess, reinforce libido and other reactions connected with sexual phenomena.

In general, however, mainly visual and euphoric rather than strictly bodily sexual after-effects are probably the essence of the alleged pleasurable erotic experiences of the habitual opium or hemp user. In this category belong also the chewers of the betal leaf, whose number shortly before the last war was estimated at 200 million, and also the eaters of 'cath', a plant which grows in the Arab region and East Africa. With reference to the latter class, Porot, the distinguished author of the monograph *Les Toxicomanies*, notes that their erotic feats ('prouesses amoureuses') sometimes terminate in spontaneous ejaculations but without signs of orgasm.

In aid of the muse

In the nineteenth century several famous poets and writers, among them Baudelaire and Gautier, were more or less heavily addicted to opium and hashish. To these men we owe some of the most introspective descriptions of chronic intoxication, including alterations in sexual function. Thus Gautier wrote: "A Romeo who took hashish would quickly have tired of Juliet. For a hashish addict the most beautiful girl of Verona isn't worth bothering about", and presumably speaking of himself he added: "The alluring phantoms which used to torment St. Anthony would have had little power over me."

Sexual love consummated in thought, not action, seems to have been the favourite *leit-motiv* of the literary addicts. Headed by De Quincey and Coleridge, the roll-call of writers of that era who were self-acknowledged drug takers includes Crabbe, Poe, Wilkie Collins, Thompson and several others. Most of them seem to have been satisfied with laudanum, which is a tincture of opium, and were therefore, strictly speaking, opium drinkers rather than smokers or eaters.

But not all were addicts. Some indulged in opium only occasionally, when under special stress. For example, Dickens, whilst on his famous reading tour of the United States in 1868, never went to bed without calming his nerves with laudanum. This and many other intriguing aspects of the association between opium and the 'romantic imagination' have been admirably surveyed by Alethea Hayter in a recent monograph devoted to this problem. Having analysed in a scholarly and critical manner all the available facts relating to the use of opiates by the writers of the romantic period, she concludes that there is no reliable evidence to support the view that the literary addicts derived any real stimulus to their imagination from the drugs. On the contrary, she thinks that in their "artificial paradise" many

Some scientists believe foetal development (shown here at three, four and five months) can be greatly altered if a woman takes LSD in early pregnancy. The most crucial period is between the 16th and 22nd day of foetal development — when a woman often is not aware she is pregnant

of them lived in what Baudelaire described as *paysage opiacé* (an opiated landscape) and De Quincey regarded as " poisonous transfiguration " produced by a blotting out of the " normal landscape of imaginary ".

But perhaps the most unexpected is Hayter's conclusion, which is that it was chiefly during the drug-withdrawal periods that some of the writers experienced a rebirth of their normal poetic impulses and enhanced literary creativity. Since drug-withdrawal symptoms may be excruciatingly painful, such experiences could not have been very enjoyable for these men. " Their paradises may have been wholly or partly artificial, their hells were real ", remarks Hayter in her postscript.

Psychedelic drugs

Two other widely publicised plant drugs belong to the category of psychomimetic or psychedelic drugs, namely mescaline and psilocybin. Closely related in action to these two hallucinogens is the synthetic chemical LSD-25 (lysergic acid diethylamide), which elicits hallucinations in oral doses as low as 0·05 to 0·3 mg. The effects of these drugs are essentially similar but their potencies differ: LSD is about 100 times more active than psilocybin, and 7,000 times more active than mescaline; taken on an empty stomach LSD or psilocybin begins to act within thirty minutes, but mescaline after an hour or two.

Newer and still more ' potent ' drugs and combination of drugs of this kind continue to haunt us; legislation in this sphere of human activity is gradually becoming more severe, but whether this approach will result in a curtailment of drug abuse remains to be seen.

The various review articles and books devoted to psychedelic experiences do not lack references to the aphrodisiac properties of the hallucinogens. LSD, for instance, is supposed to produce greatly heightened genital sensitivity in some people. But there is general agreement that the sexual emotions evoked by the psychedelic drugs are in the nature of illusory platonic affections and do not lead to sexual arousal. They seem to form part of a syndrome referred to by Porot as *clownerie psychique*. According to Wakefield, a hallucinogen party looks not so much as a scene from *La Dolce Vita*, but more like a slow-moving Beckett play. In short, the setting for love-making which the psychedelics induce is one of an ' orgy of vision ' rather than real sex.

Nevertheless it cannot be denied that in selected cases psychedelics might be of help to the psychotherapist in the treatment of frigidity, fetishism, impotence, homosexuality and possibly other conditions. But e wonders whether such treatment will ever be lly practicable since even single doses of hallucinogens are known to produce disastrous effects in susceptible persons.

One other fundamental problem concerns the effects which LSD and similar compounds exert on the gonads and germ cells. Damage to chromosomes has been claimed for LSD in experiments in vivo and in vitro, in both body and germ cells. Evidently a great deal more research is needed in this area if we are to avoid cytogenetic damage with all its attendant evils and long-term effects.

The psychopharmaceuticals

Along with psychedelics certain other drugs, commonly designated as psychopharmaceuticals, are nowadays available for the treatment of emotional upsets including sexual disorders. On a clinical basis they are grouped as anti-psychotic, anti-anxiety and anti-depressive agents. The group of anti-psychotic drugs includes the phenothiazine compounds, such as chlorpromazine, and the rauwolfia alkaloids, such as reserpine.

Irregularities of menstruation and lactation are not infrequently encountered with the use of phenothiazine drugs. In men phenothiazine derivatives can produce feminising effects such as the development of breasts. In addition, there may be disturbances in the ejaculatory process. In fact, since some of these drugs inhibit ejaculation without apparently altering potency or ability to reach an orgasm, they have been prescribed in the treatment of premature ejaculation.

The rauwolfia alkaloids, too, can affect sexual function, and reserpine in particular has been blamed for feminisation, loss of libido and inhibition of ejaculation.

Of the anti-anxiety and anti-depressant agents, the former seem fairly innocuous, but the latter are known to have anti-ejaculatory properties, and both phenelzine and imipramine have been accused of delaying ejaculation and causing impotence.

Drugs which cause much concern, especially in the young, are the amphetamines, which are popularly known as purple hearts, dexies, black bombers, etc. As with opiates, cannabis and LSD, there is some evidence of a link between the abuse of amphetamines and certain types of sexual incompetence or deviation. It seems that in some cases amphetamines are capable of stimulating libido, but on the whole they reduce the mating performance. In that they resemble the hard drug, cocaine. Cocaine addicts may boast of increased sexual desire but this often coincides with loss of sex potency and with perversion as well.

In general, observations relating to drug dependence and sex problems are insufficient and far too many statements are based not on objectively scientific but on impressionistic evidence, of the kind that Masters and Johnson like to refer to as 'phallic fallacy'. The reasons for this unsatisfactory state of affairs are manifold, but one of the most important ones is the variability in people's responses to the various drugs discussed above. Just one illustration to this is that doses of amphetamine, for example, which in a normal person fail to evoke psychotic responses, can greatly increase hallucinations in a schizophrenic.

Complications also arise from the fact that drug fanciers seldom stick to one drug and often use several substances at the same time, say amphetamines with barbiturates. Such dangerous combinations are causing much concern, because drugs, like drinks, do not mix well. The worst problem is that users of soft drugs frequently progress to hard drugs, a situation from which for many there seems to be no return.

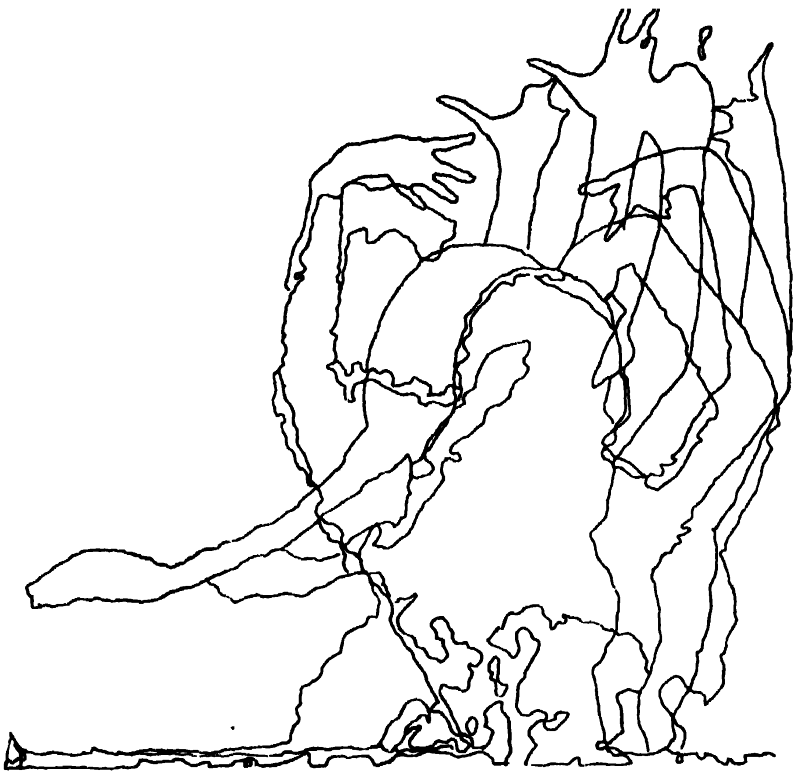
Sexual effects of alcohol

The analysis of effects produced by drugs on the sexual behaviour in man would be incomplete without a brief reference to alcohol. Alcoholism in men is well known to result in a progressive decline of sexual power. This in spite of the fact that when taken in moderation alcohol can in some instances act like a weak aphrodisiac, presumably by removing minor inhibitions. In the long run the effects of alcohol consumption on libido, erection and ejaculation are all adverse.

By contrast, alcohol as such has little direct effect on the spermatozoa. Many years ago Ivanov showed that the motility of dog spermatozoa was not altered in the presence of 5 per cent alcohol and he even managed to obtain normal puppies from a bitch inseminated with sperm plus 10 per cent alcohol. These observations have been reinforced by more recent ones at the Warsaw Zoo, where it was observed that as much as 20 per cent alcohol did not alter elephant sperm motility in vitro.

The resistance of spermatozoa to alcohol in vitro is interesting since, when ingested or injected, alcohol quickly passes into the semen. Similarly, many drugs, amongst them the sulphonamides, the salicylates and thalidomide, all penetrate readily into semen, where they can be detected after oral or parenteral administration.

One other ingrained social habit, namely the smoking of tobacco, is now also suspected of being detrimental to the reproductive function. Regular smoking during pregnancy has been claimed to retard



the growth of the human foetus, and is held by some medical authorities to be responsible for cases of stillbirth and miscarriage.

Other links between drugs and sex

Obviously it is difficult as yet to define accurately the causal links between drugs and sex and the ethical implications of this relationship. Although the literature on this subject rapidly grows, the amount of precise scientific information is limited and too many observations are subjective, based on speculation or prejudice with strong emotional overtones, and even sheer phantasy.

There is no doubt that drug addiction, as it relates to sexual function, tends to be rooted in fundamental personality disorders. Young people frequently seem to indulge in drugs for their presumed pleasure-giving properties, and in the hope, however ill-founded, of prolonging sexual gratification. To them the drugs serve as sex substitutes. Up to a point this also applies to older men, particularly those suffering from impotence, imaginary or real, due to ageing. In these individuals drug dependence stems from decreased capability and is a pathetic attempt at overcoming their sexual incompetence.

Some wise old men, however, do not succumb to drugs, and find healthier outlets instead. Referring to his ageing father, J. R. Ackerley in his masterly autobiography, *My Father & Myself*, writes: " The fact that women and sex were often in my father's thought, in the form of the smoking-room story, was easily written off as a compensation, the reminiscent after-glow of a lost libido, that substitute amusement of the old, for actions they are no longer able to perform." And he goes on to say that these smoking-room stories should be taken for what they are, namely as rather " wistful jollities of the sexually abdicated ".

If only one could persuade sexually incompetent young men to tell smutty stories instead of ruining themselves with poisons of all sorts!

But to ' persuade ' anyone, whether young or old, in matters of sex is not a simple proposition. Like compulsion, persuasion must be applied from a position of strength (of mind, of course, not brute force): one needs confidence that what one offers is the correct advice. Much of the weakness and indecision today is due simply to our incomplete knowledge of the physiology and pathology of basic human reproductive processes. Fortunately, the science of reproduction is advancing rapidly and the clarification of much that is now obscure can be expected in the foreseeable future.

Our ethical attitudes, however, may take much longer to sort out, because as Julian Huxley aptly pointed out during a conference on Man and his Future: " Man's exploration and control of external nature has far outrun his exploration and control of his own nature."

[Dr. Thaddeus Mann, FRS, is Marshall-Walton Professor of the Physiology of Reproduction and Director of the Unit of Reproductive Physiology and Biochemistry, University of Cambridge, UK.]

BLUR & BRIGHT

What does America look like? Ask the Russians!

THAT is exactly what the Maine Museum did. It wanted an aerial picture of the State of Maine in Northeastern USA, and for nearly two years, pestered various US agencies for the picture. NASA, the US space agency said it did not have such a picture. The US Weather Bureau said it did not have such a picture. The US Air Force said it possibly did not have such a photograph, but even if it did, the material would be " classified " and non-disclosable.

Then a disgruntled staff member of the Museum rattled off a request to the Russian Embassy in Washington, more in jest and less in hope. After some months the photograph arrived, captioned in Russian: " A montage of the region of the State of Maine (US), photographed by the Soviet meteorological artificial satellite of the Earth."

A spoof on the patriots and sticklers for security *a la* Ian Fleming? Also one on technology's super-ego: the more advanced you become, the more duplicable you are. You shouldn't have laughed at the golden rule, Mr. Fleming! When you can no longer hide your secrets, be wise and live and let live.

When things go wrong, look after your looks!

THE sea gull does it, the gorilla does it, also the young city woman who has just bumped her car into another. Make a sound while the gull is warming its eggs and it will dive straight for the nearby water and start rigorous bathing. Let your jeep get near a 250-kg gorilla in the African rain forests and he will start pounding on his chest with great fury. Or, watch the young woman in the midst of the traffic jam she has created. As the other driver swears angrily and a police car looms up, the woman brings out a mirror and starts adjusting her hair. Find anything common? All three are demonstrating " displacement activity ".

Flying saucers? No, plate-like lenticular cloud formations associated with mountainous terrain as seen over Brazil. (Photo: Aerial Phenomena Research Organisation)

For each of them, there are two logical responses open. But, instead of choosing any of the most obvious alternatives, each makes an apparently illogical response. The gull can go on nesting or exploring; instead it decides to bathe. The gorilla can stand its ground or flee; instead it thumps its chest. The guilty woman can run away or argue belligerently; she decides on a face-lift.

According to J. J. Van Iersel and A. C. Bol, two anthropologists who have made extensive field studies, animal behaviour patterns are arranged in a kind of hierarchy. When two impulses of equal importance occur in the hierarchy, they cancel one another out and neither is performed. Rather, a behaviour pattern of lower rank in the hierarchy is set loose.

The demagogues — Hitler, Mussolini — must have known this, to some extent at least. The wild cheering rallies they commended were the perfect examples of displacement behaviour by a crowd. Today, psychiatrists say they may be able to turn the table. By *inducing* displacement behaviour on a formal, planned basis, a lot of tension and violence may be pared off — from marital life, from college campuses and maybe even from international feuds. There may be something in it after all. Next time you see a pretty woman primping on the street, do not say she is being coquettish — she may be in trouble.

How to Succeed in a New Technology Enterprise

New companies based on new technology have been founded in record numbers since 1950 in the USA. Here is a summary of research on the criteria for their success — or failure. These lessons on entrepreneurship may prove to be more than informative for the Indian hopefuls

EDWARD B. ROBERTS

TODAY is the age of entrepreneurship. The formation of new companies is increasing — and at a rapid pace; and the average entrepreneur is younger than his entrepreneurial counterparts of a few years ago. What kind of person is today's entrepreneur? What background and talents does he bring to his new enterprise? And what are his chances of success?

This article is based on five years of research conducted at the Massachusetts Institute of Technology's Sloan School of Management (USA) on the formation and growth of technically-based enterprises. In this article I shall review the characteristics of the typical technical entrepreneur as revealed in our studies, some aspects of the process of starting new companies, and — especially — the apparent keys to success and failure of new technically based companies.

Though many of us could anticipate the pattern of growth of the new companies which we studied, their overall success and survivability is something that we did not anticipate.

For example, our first study was of a group of 30 companies that emerged out of the MIT Instrumentation Laboratory. At the time we studied these companies — in 1964 and 1965 — the average company was about five years old and was doing slightly over $1 million (Rs. 7·5 million) of business. That is good performance by any standard; but the more impressive thing is that after five years there were surviving approximately 85 per cent of the companies initially formed. Indeed, approximately 80 per cent of all the 250 technically based enterprises that we have examined have survived, and now average about five years old. Our figures make it clear that the first several years are the tough ones and that those surviving the first five years are likely to survive thereafter.

Survival is not the same as success, of course although for many entrepreneurs survival may in fact be sufficient success. We typically define enterprise success in such businessmen's terms as growth, sales, profitability, and the like. But entrepreneurs do not necessarily have those objectives in going into new enterprises; for some, simply producing an organisation that has survivability is a sufficient reward — even if it yields no greater income to the entrepreneur than he made in his previous employment.

What about the characteristics of the men who formed these companies? The entrepreneurs are indeed an intriguing lot, and in looking at them we are struck by several key characteristics. To report them is not to say that every entrepreneur must have these characteristics to be successful, but the reader may indeed wish to compare himself and his associates with these prototypes in considering

Edward B. Roberts, an active consultant to many firms, is co-founder of three companies and director of several new-technology enterprises. He is on the staff of MIT's Sloan School of Management. He holds degrees from MIT in electrical engineering and industrial management and a doctorate in economics. This article is reproduced from MIT's *Technology Review*, December 1970.

whether starting a new business is going to be his thing.

The first characteristic of the entrepreneurs that we note is one aspect of their family background. In every single one of the samples that we studied, about 50 per cent of the entrepreneurs came from homes in which the father was self-employed. The likely rationale may be put this way: if your father was in business for himself, you have probably been exposed to a background of business conversations in the home as part of your growing up; you tend more, whether you realise it or not, to think in business terms; you identify with the vocabulary and concepts of entrepreneurship — employees, suppliers, pricing, profit, cash flow. This is not to say that such a background is essential; but we think that this kind of entrepreneurial heritage is an important force that tends to push people toward starting new business.

The second notable aspect of the entrepreneurs is age: the average entrepreneur coming from an MIT laboratory was 31 or 32 at the time of starting his company. (But it is important to note that these data pertain to companies formed typically in 1961 or 1962. I am convinced by observing the current scene that the age of entrepreneurship is indeed trending further downward, and this trend is probably going to continue.) In fact, very few entrepreneurs are over 40 at the time of company initiation. The relative youth of the entrepreneur seems significant in two ways.

The older a person is, the greater his commitments to present patterns of activities — family, organisation, outside activities, community — and the greater the difficulties of breaking those patterns. Not only are there psychological difficulties; there are in fact likely to be meaningful entanglements and relationships with others. Breaking these associations may pose costs very much greater than any possible reward. There are exceptions to the general pattern of youth; for example, two companies we studied were formed by MIT professors who had reached the age of 65 and were put on retirement status; both companies were successful.

The point to be made in writing about these two exceptions at age 65 is not simply to say that some few entrepreneurs were not young, but rather to argue the second characteristic of youth: the real requirement is vigour and energy. To start a company and put it underway requires on the part of the entrepreneur a tremendous amount of energy, and he must put forth an immense amount of effort. These abilities are usually characteristic of younger people — but not always. When we speak of the typical youth of entrepreneurs, what we really interpret our data as saying is that successful entrepreneurs are people who are willing to break out of the entanglements of their present situations. They are able to commit generous amounts of their time, effort, and energy to the starting of a new enterprise.

A third characteristic of the entrepreneur is his education. Our study included only entrepreneurs who left advanced technology organisations, so technical education itself was expected. But it is significant that the typical entrepreneur that we examined had a master's degree — usually in engineering, sometimes in science, sometimes in other fields — and had in fact gone somewhat beyond the master's degree by taking several additional courses. We had entrepreneurs with doctorates in our sample, and we had others with only bachelor's degrees and even some without collegiate degrees. But the master's seemed to be the most specific symbol of participation in advanced and advancing technologies.

Background

The entrepreneur was not necessarily a technical genius; he was not necessarily the inventive mind behind the company; he was not necessarily the man who came up with the brilliant technical advances himself. But our studies suggest that if the basis of the company is technical — if the new enterprise is working at the forefront of a technology — then its founder probably should have sufficient background through education and experience to participate actively in that technology, to understand the work and contributions of others in that technology, and to put developments in the market place in their proper context in relation to the advancing technology. The master's degree simply represents an appropriate degree of understanding and background.

A fourth characteristic of the entrepreneur is suggested by our finding that entrepreneurs usually have come out of development rather than research activity. This is important in terms of which people are suited for entrepreneurship and which type makes effective entrepreneurship and which type makes entrepreneurs. The development process, in contrast to research, involves translating ideas and skills into some form of utilisation — hardware, production, whatever the actual specific objective. In contrast, research is a process of the creation or enlargement of knowledge. Entrepreneurship is in fact more akin to development — to applying skills and knowledge to create something that is real and is clearly useful. The man who has been working in development activities has already come closer to the things expected of him as an entrepreneur than has the man on the research side of the organisation. So a development background is not only a correlate of entrepreneurship; it is also a statement of experience applicable in an entrepreneur undertaking.

What about the companies formed by the entrepreneurs whose achievements we have studied? Remember that our data are for companies formed typically about 1962; to the extent that readers believe 1970 is different from 1962 or 1963, they may argue that new phenomena and changed circumstances render our data obsolete. But we suspect that the obvious changes — the tighter money market, the recent reductions in government contracts, new technologies not available ten years ago — are superficial, that most of our basic findings are as valid for companies formed today as for companies organised eight years ago.

One-man entrepreneur

Among our findings on new firms is that the one-man entrepreneur is an interesting idea, but that most companies are formed by two or more people. The one-man entrepreneur succeeds less frequently than the multi-man organisation. There are several reasons: the single-man entrepreneur — partly because he is alone and partly because of the very orientation that makes him go it alone — tends to form a very different kind of company than the multi-man entrepreneurial group. The one-man company is a research-oriented firm through which the entrepreneur himself can do his " thing " — the work at which he was expert in his previous employment. His opportunities are limited; he must be his own marketing man; he must be his own critic; he must supervise his technical work; he must organise his own financial and personal management. He can run such an organisation out of his back pocket or out of his garage or his living room.

The larger the group of entrepreneurs, the greater the likelihood that this group will utilise themselves in a way demanding multiple contributors and multiple skills. For example, the greater the number of founders, the greater the likelihood that the new company will be devoted to manufacturing or repetitive services — especially today, computer services. When several entrepreneurs get together to form a firm, they usually feel that their complementary skills and backgrounds permit each to take a relatively different role in the new enterprise — production, product development, control and operations, or marketing. The research company needs few relatively different roles.

The kind of enterprise that is planned affects not only the number of entrepreneurs required; it also influences the amount of capital needed and the sources from which it may come. One of our findings has surprised many people in the venture capital field: the typical company started with very little capital. The typical total was $5,000 to $8,000 (Rs. 37,500 to Rs. 60,000) and it was usually contributed by the entrepreneurs themselves, their families and friends. Formal sources of venture capital were seldom tapped, at least in the initial stages.

But our study also suggests that the larger the amount of initial capitalisation and the larger the number of initial founders, the greater the likelihood of the company's later success. Hence this advice to would-be entrepreneurs: if you feel that you cannot start a business because you do not yet have that multi-hundred-thousand-dollar kitty that you think you need, better reconsider your motives and re-examine your convictions. If you really have strong entrepreneurial motives and strong convictions that you are going to succeed, there's a very good likelihood that you can in fact make a start with what you personally have available and what you can raise from family and friends. (The figures cited pertain to companies started generally in 1962 and 1963. A large number of new entrepreneurs today seem to feel that to start a company off properly now they need several hundred thousand dollars. This may be one of the requirements that has in fact changed in the past decade.)

The companies we studied achieved a tremendous amount of what we call technology transfer — their entrepreneurs took advanced technology out of the organisation where they had been employed and moved it into the market. Some — the largest single number — did so immediately by forming their companies at once. But most entrepreneurs first went to industry; they did so, often fully convinced that they would soon leave and set up their own businesses, but they felt that they first needed practical experience — as controllers, in marketing, in project management — which they expected to gain in industry.

But those who delayed their entrepreneurship paid a heavy price for this experience; they took far less of the technology available from their original laboratories into their companies. The entrepreneurs who started their new companies immediately upon leaving the advanced technology laboratories tended to utilise and exploit laboratory technology to the greatest extent in their new enterprises. Men who delayed sometimes forgot certain aspects of the new technology; it was less relevant because the market had moved on; the demand was less keen because the once-novel technology was no longer a novelty. It is clear that the longer the entrepreneurs delayed forming their companies after leaving an advanced technology centre, the less they actually took

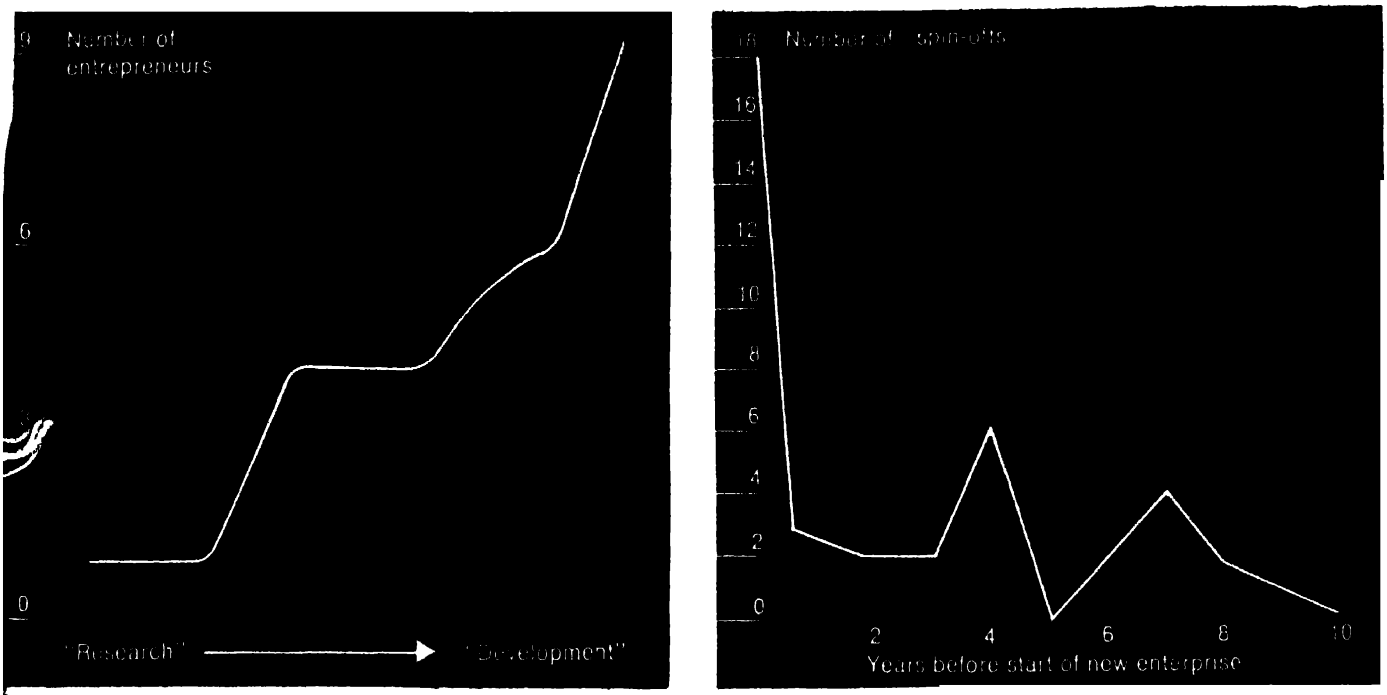


Fig. 1 The previous assignments of 39 entrepreneurs who " spun off " from one large electronic systems company studied by the MIT entrepreneurship project are shown on a frequency plot with a scale going from basic research to the most applied development activity. The largest number of entrepreneurs — not just out of this organisation but out of all the organisations studied — came from developmental activities. The largest single number of companies which spun off from MIT's Lincoln Laboratory were established immediately after their founders left the Laboratory. But the median company was not formed until 2½ years after its entrepreneurs had left the Lincoln staff. In the meantime, the company founders usually worked in industry, often for the explicit purpose of gaining what they felt was relevant and important business experience that they felt would help them set up their new company

advantage of the special technological knowledge and skills that were in these laboratory organisations.

The deciding factors

What factors led to success or failure for the new companies we investigated? What things make the difference between high and low performance when performance is measured in terms of sales growth, profitability, and persistence?

The first factor we list is a high degree of technology transfer. Those companies that were founded on the basis of rapid and direct translation of advanced technology from the parent laboratory to the new enterprise were the ones most likely to succeed. Companies formed by entrepreneurs who sought business experience that they thought relevant and critical to company success exploited technology to a lesser extent and were less successful as business organisations. Success for a new technologically based company depends on moving quickly into the market-place with a level of technology that is not there.

Unique technical ideas are the one strongest competitive advantage that a fledgling company has potentially available to it. If the entrepreneurs lose this advantage while trying to gain business experience so they can compete on the basis of business acumen, they lose. If they try to compete on the basis of marketing experience, they lose. Indeed, if they try to compete with established industries on the basis of any one of the skills in which the established industries are experienced, they are probably going to lose. The most successful of the companies that we studied were those that most immediately and most directly put advanced technology to use.

Moderate educational level seems to correlate with business success, in the sense that the lower performers among entrepreneurs were typically Ph Ds. This is not to say that the additional education was damaging; it is rather to suggest that the personal characteristics of the man who is willing to go through the process of getting a Ph D are different from the characteristics of a man most likely to be a successful entrepreneur. A Ph D programme involves — in addition to advanced study and research — a fair amount of regimentation, regulation, committees, writing, and the like. The man who has the Ph D probably has a very different set of motivations from the man who wants to get on with it, to start putting ideas to work and make something happen. (It is also true that I know several very successful Ph D entrepreneurs. So we are not saying that if you have a Ph D, give up. We are saying instead that if you have a Ph D, you should think your motivations through more carefully, ask yourself if you are really willing to sacrifice the time, energy and other commitments to try to create a driving, successful organisation.)

Our research suggests that the successful entrepreneur does not require explicit managerial training or experience — a finding which totally disagrees with the view of most venture capitalists. What is needed to be a successful technically-based entrepreneur are not necessarily training and experience — but a managerial point of view, a set of attitudes that are clearly managerial in substance.

Attitudes

These attitudes appeared in our research findings in at least three ways. The successful technical entrepreneurs were those who perceived the need to bring into the company people with business skills and business experience. They respected the problems of management, control and administration and accepted the need to bring specialised capabilities to bear on the business functions of the organisations. Similarly, the successful companies had a formal marketing department. One of the unfortunate things we were taught implicity as undergraduates is an arrogance of technology that leads some entrepreneurs to believe that the market will beat a path to the door of anyone with a unique and important technical idea. That notion is as wrong as can be. Even the great technical idea needs to be sold energetically and effectively to be the basis for a successful new firm.

Finally, the founders of successful companies indicate greater concern for personnel matters in their organisations. They were oriented to providing challenge and satisfaction for their employees as well as themselves.

Thus the effective technical entrepreneur is perhaps surprisingly lacking in management expertise, but he is well equipped with balanced managerial attitudes and perspectives. He appreciates the need for acquiring relevant skills to solve company problems — whether these be administrative, marketing, or other personnel resources. He places a balanced emphasis on integrating these several functions into the technological base he has brought to the new firm.

Psychological tests

Further to confirm these impressions, we have made a series of psychological studies of 50 entrepreneurs who founded their own technical companies. Though even we retain many reservations about the reliability of these psychological tests, one characteristic showed up quite convincingly: entrepreneurs who are successful have a very high need for achievement. In psychological terms, need for achievement describes a person who seeks to fulfil three conditions in any situation: he seeks moderate risk — not high risk and not low risk — so that the probability of failure is neither so high that he is unlikely to encounter success or so low that there is no challenge. He looks for a situation that offers tangible measures of success. These measures can be in financial terms or — more likely — they can be in terms of a viable, sustained, growing organisation: products selling in clear-cut markets, good technical and market reputations, steady growth with reasonable financial return. And he looks for a situation where he himself can be the primary cause of success.

Most high-performing companies we studied were run by entrepreneurs who had what is defined as moderate need for power. This psychological term relates best to the leadership or managerial style that an entrepreneur will practice. He is neither an authoritarian nor an autocratic leader who will take absolute control of any organisation he forms; nor is he a laissez-faire leader who lets everyone in the organisation do his own thing without regard for central goals. The authoritarian running a one-man show will prevent other people from contributing to his success, practically assuring that his company will use fewer resources than it has available to it. At the opposite end of the scale, the man with a low need for power lets everyone be a law unto himself, and a new company can ill afford to disseminate its resources of manpower and capital without central goals and without management that keeps a sense of direction.

The ideal entrepreneur is the middle-of-the-roader who is willing and able to run what we call a participative organisation. He is indeed the boss, pointing out central goals and central objectives. But he also shares responsibilities with subordinates and colleagues who have latitude to make their contributions as best they can.

According to our studies this ideal entrepreneur has chances of success in taking a new technology into the market-place which are better than eight in ten.

BRAIN TEASERS

Hotplate poser

"MUMMY can I help you clean up the kitchen?"

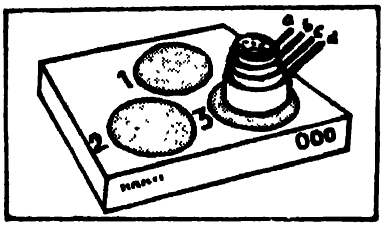
"Yes, Priya. You can move those saucepans I have been polishing to the back of the cooker. They are in my way."

"Oh, that won't take long."

"Now don't rush it! Move them one at a time and mind you don't try to stack a big one on a smaller one — they might overbalance."

Priya soon found her mother's seemingly simple instructions not all that easy.

How would you set about moving those four saucepans from one hotplate to another until all are stacked on hotplate No. 1?



Remember, they must be moved one at a time, and on no occasion must a bigger pan be perched on a smaller one.

Priya managed it in 20 moves. Can you improve on that?

The murmurers

THERE had been some mild murmurings at the women's social club recently.

The annual election of officers had just been held to fill the posts of president, secretary, treasurer and outings organiser.

These four office-bearers form the committee, and some of the ordinary members felt that the committee was monopolised too much by one family.

Admittedly, the secretary and Mrs. Thomas were sisters and it was also true that Mrs. Gupta was the secretary's daughter, but it was certainly not true (as one ill-informed member tried to suggest) that the treasurer was the outings organiser's aunt.

Moreover, the president had pointed out that she herself was no relation whatsoever to any of her three colleagues on the committee.

Mrs. Singh, who happened to be the youngest member of the committee, had told the critics that if they were dissatisfied with the way the club was run, they had only themselves to blame because Mrs. Banerjee, Mrs. Thomas, Mrs. Gupta and herself were the only four nominations for the four vacancies and were therefore all elected unopposed.

Can you determine which of the four offices was held by each of the four women named?

Alive and kicking in a matchbox

A BANANA skin, two nails, half a toothbrush, a piece of blue glass, several scraps of paper and a bee in a matchbox—still alive if not actually kicking. The things that boy managed to stuff in his pockets!

Lata sighed, emptied the pockets, freed the bee and consigned the rest to the dustbin.

"Where's my bee?" asked Ramesh half-an-hour later.

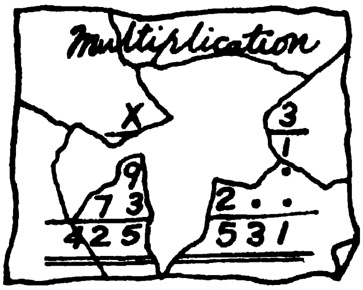
"I let it go," said Lata. "And I have put the rest of the stuff where it belongs — in the dustbin."

"What about my homework?"

"Homework? You don't mean to say . . ."

But that is just what Ramesh did mean to say — and Lata spent the next half-hour trying to piece together those scraps of paper she had transferred from pocket to bin.

But there were some fairly big bits of the jigsaw missing, and when she had fitted together all she could find, the arithmetic exercise still looked as the drawing shows.



"You threw it away, Mother, so it would only be fair if you worked it out for me again," declared Ramesh, and Lata did feel some moral responsibility for the task.

Assuming Ramesh had originally got the exercise right, could you have figured out what the missing numbers were?

Xeno

(Solutions next month)

(Solutions to last month's Brain Teasers on p. 57)

Have fun with the family

Enjoy Nescafé -the coffee with life in it!

100% pure coffee. Made from South Indian coffee beans. Rich, reviving coffee — Nescafé.

So quick to make, so good to have—any time of day.

NESCAFÉ

A Nestlé product

NCE 6371

BOOKS

The Brain — Towards an Understanding by C. U. M. Smith, Faber and Faber, London, 1970, 17 chapters, 392 pages, 90 shillings.

THE growth rate of the number of topical books has an element of positive feedback. The very first book is shy to appear, the second and the third less so, the subsequent ones cropping up at an accelerating rate. This is now the situation with books on molecular biology, although the heyday of this discipline is alleged to be over. In a recent lecture published in the weekly *Nature*, Francis Crick voiced the same sentiment when it came to predicting the major achievements of the life sciences at the turn of this century. Opinions seem unanimous that the most fascinating area of biological research in the coming decades will be the science of the brain. The trend is already evident. Biologists, physicists, computer scientists and mathematicians are beginning to take a look at " the most intricate piece of matter ", the human brain.

Books on the brain, however, are few, particularly the ones which care to introduce the uninitiated into this area. Smith's book is a very welcome addition to this small set. Considering the fact that one has to cover the fairly extensive ground of anatomy, physical chemistry and physiology of the neuron, a single volume can hardly afford to be a treatise in depth. To that extent this book borders on being popular, yet the treatment is quite professional. Mr. Smith deserves to be congratulated on being able to confine within 400 pages a treatment that begins with elementary thermodynamics and ends with a discussion on free will.

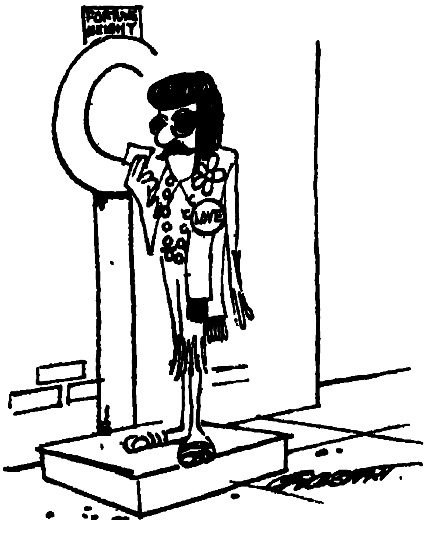
The first few chapters prepare the reader for an understanding of the structural and functional units of the nervous system, viz the neuron and the synapse. Leaving out details, the author gives a good glimpse of the mechanism of impulse propagation. Sensory receptor cells are dealt with in a separate chapter. Once the basic components have been outlined, the author goes on to discuss a number of specialised cell systems like some crustacean ganglia and a number of insect visual systems. Introducing some of the lower integrative systems, he prepares the reader for what is to follow in the second half of the book, namely, a review of our current knowledge of the functional aspects of the vertebrate brain. There are seven chapters devoted to this area.

It starts with a discussion on the evolutionary aspects of the vertebrate, particularly the mammalian brain and goes on to topics like motivation, perception, memory and consciousness. The last chapter is given to a discussion on the brain-mind relationship with some philosophical undertones. However, the arguments in this chapter, as elsewhere in this book, possess the persuasive clarity that distinguishes most of science from metaphysics. Wherever there is speculation (mostly in the last three chapters), it is labelled as such and the result is entertaining. The recent experiments on a possible chemical basis for memory and precise chemical studies of single cells of the brain (to hunt for the molecular correlates of learning) are described with lucidity. Mr. Smith goes a step further when he discusses, for example, how the alteration of ionic balance caused by neural activity in a cell could possibly bring about the synthesis of specific proteins and thus establish structural connectivity between neurones. Permanent memory traces could thereby be created.

This is not the place to discuss the plausibility of such a model. But this illustrates the emphasis throughout the book on basing speculations on experimental data. This makes the book instructive and at the same time interesting. The citation of fairly recent original papers also makes it particularly useful. The book is profusely illustrated with line drawings and occasionally with plates, the figures being detailed enough to convey the message, and yet bereft of complicating details. The inclusion of a glossary (by no means comprehensive) and a selected reading list will prove useful not only to the general science reader but also to new entrants to neurophysiology. If a second printing is planned, printer's errors should be rectified.

In conclusion, this is a very balanced account of our knowledge of brain and is highly recommended for the general reader as well as for the serious student.

P. K. Maitra



"You are going on a trip."

THE CROW

IT is a dark and cunning airborne scavenger, a villainous bird. Its caw evokes a legacy of hatred. The crow hops about in the lores of gods — and of witches. In the *Ramayana* there is a story of a crow that went beserk. It drew the wrath of Rama, when it teased Sita, and lost an eye. For long, many believed the story. They believed the crow had just one eyeball for its two eyes. Its habit of cocking its head lent further credence to this belief. This peculiarity, however, is due entirely to the position of its eyes which are placed on either side of its head, leaving a blind stretch in the centre. This type of vision — monocular vision — is a disadvantage when it comes to judging distances: the eye needs to be brought directly in line with the object. The advantages, however, include longer range vision and quicker powers of accommodation from telescopic to microscopic view.

The crow belongs to the family Corvidae, consisting of about a 100 species of conspicuously coloured birds, which include the big black sombre rooks, the ravens, the jackdaws and the smaller brightly coloured jays and magpies. There are seven species of crows in India of which five are resident. The common house crow, *Corvus splendens splendens*, gets its name from its glossy plumage. Both sexes look alike.

It is a sturdy bird with feet adapted for perching and for walking. Its shoulder joints are very flexible allowing it to take off even vertically. It can attain speeds of 50 to 70 kmph while migrating.

It is a parasite on man to a great extent and always builds its nest near human habitation just before breeding. The crow breeds twice a year but not in the same nest, and it may even change its mate.

The position selected for nesting is usually the fork of a tree, uninhabited houses, verandahs and sometimes even electric installations, where it often meets its doom from short circuits caused by its nesting material, which includes metallic wires and scrap. Materials used for the nest vary according to availability. Twigs and wires, lined with softer materials like hay, rags or wool are the most commonly used. There are even cases of nests being built entirely of spectacle frames (near an optician's establishment) and tin scrap (near a tin factory).

The cock and hen crow vie with each other in collecting building materials. The actual construction, which takes about two days, is done by the female alone. The male, meanwhile, never lets his mate out of sight.

The number of eggs ranges from four to five and sometimes six. They are small and bluish-green, flecked with uneven brown, purple or reddish blotches. The crow begins to brood with the laying of her first egg; this helps to restrict the brood size.

At this stage, the crow in turn becomes the target of other parasites. The koel and a type of wasp, *Passeromycia heterochoeta*, lay their eggs in its nest. The koel merely passes on its parental responsibility to the crow. The grubs of the wasp, however, suck the nestlings' blood and kill them. Were it not for such setbacks, the crow population would long have gone out of control. Otherwise, the crow has few natural enemies and as it is omnivorous, its struggle for existence is minimal.

The young are born plumeless and take a long time to reach the adult stage compared to other birds. As their childhood is comparatively long, their intelligence is consequently higher. Hungry and greedy, the young crows eat a lot, usually half their body weight. They can very easily consume their full weight!

Being a nest robber itself, the crow is extra-cautious with its own. The parents hunt in turn and rarely do they leave the nest unguarded. They are very aggressive and bold, not allowing other birds to trespass into their territory. Even man is not spared if he tries to get to the nest. As a group, crows have been seen to attack birds of prey like owls, apparently as a precaution against any attack on their nests.

Even after the young have fledged they are fed by the parents, who seem to be able to recognise them by their cawing. The young are incapable of recognising the parents and beg any passing adult for food. The fledglings can be recognised by their deep red mouths and indistinctly marked plumage.

As it is a gregarious bird, communication plays an important role in the life of the crow. It has developed a wide vocabulary. The cohabitation of different species has led to further improvements in its vocabulary. The syrinx of this versatile chatter box is controlled by seven pairs of intrinsic muscles, whereas most birds have just three pairs and the pigeon only one. It alerts its fellows to danger or leads them to a better source of food by cawing in different ways. Cawing also denotes the stage it has reached in the sexual cycle.

The crow is an early riser — the first to get up awakes the others by its incessant cawing. Out on a hunt, they always leave together. Their community roosting places, at times having as many as 50 nests, are sometimes used by bats in the daytime.

This resourceful omnivorous bird eats anything it can lay its beak on, be it corn, grain, worms, insects, eggs, the young of other birds or even carrion. It happily steals food, often aggressively, from its weaker opponents, and follows birds of prey to partake of their feast. Freshly turned up soil or ripening cornfields are also its hunting grounds. Picking off ticks from the backs of cattle and even picking at its wounds are among its pastimes. A thief and a robber, it is also a scavenger, perching on dustbins to gorge itself. It is clever enough to connect smoke

Crow fledglings cawing for food

A lesser raven

with outdoor cooking, and calls to its fellows when it locates abundant food.

True it is a greedy bird, but it often kills merely to amuse itself, without any intention of eating. It harasses lizards or frogs to death and flies off in search of other such sadistic amusement.

Nature has not endowed it with any protective coloration. But then it does not need any as it has few enemies and can take good care of itself. Instead, the conspicuous black colour helps it coordinate its movements with the rest of the group.

Its gregariousness leads it into many conflicts within the colony but inter-species hostilities are more common. Large groups of crows often meet together to caw and condemn one of their fellows — disabled or diseased — to death. However, they seem to be capable of telling the difference between natural and unnatural defects. A bald crow is never killed as baldness is a temporary phase.

Emboldened as it is, knowing man's weak points, it is still wary of him. The value of the crow to man, weighing out all its merits and demerits comes to neutral. Its scavenging and insectivorous habits compensates for its stealing and destruction of crops. But if you take into account the entertainment it affords to an interested man, the balance tips in its favour.

Sumati K. Sampemane

YOU TOO CAN DO IT

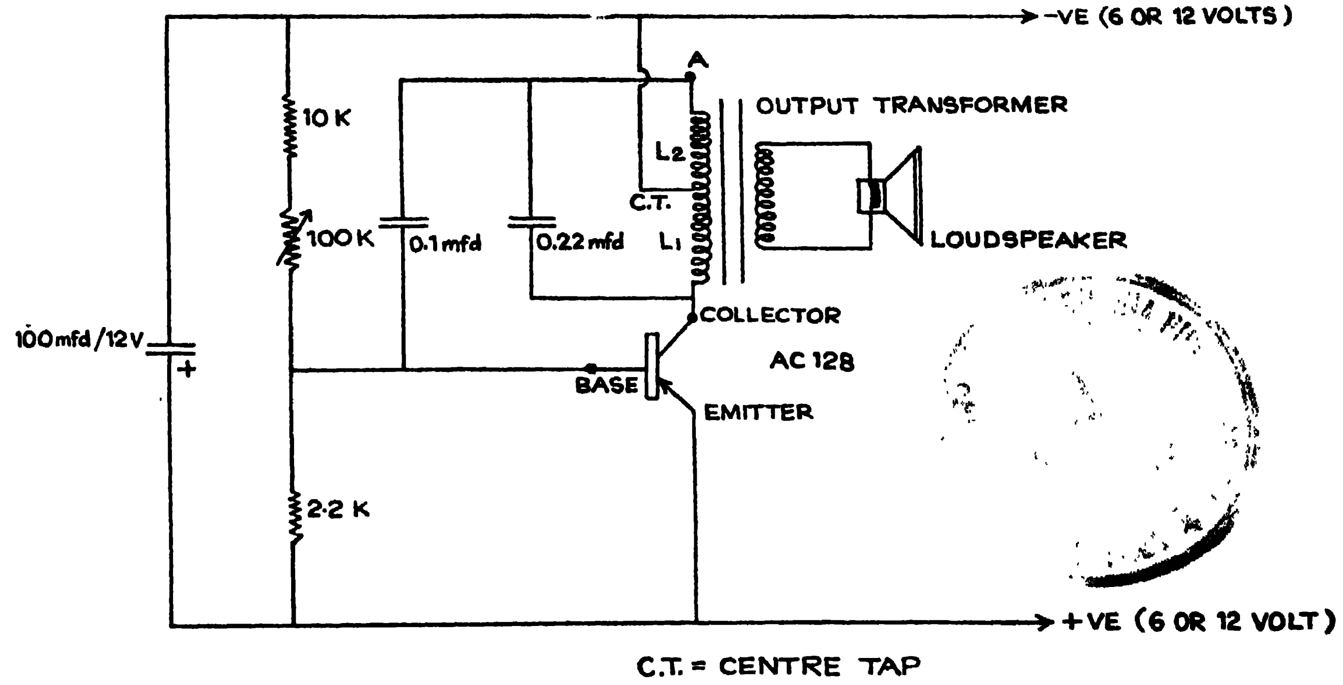
Transistorised Beeper

THE simple circuit shown here is of the transistorised audio oscillator. The circuit is arranged in such a way that it can be operated satisfactorily on either the 6 volt or 12 volt batteries of the car. The frequency of oscillation can also be changed within certain limits to get a suitable tone from the loudspeaker by adjusting the potentiometer.

The transistor is a current amplifier; by using a transistor one can control comparatively large collector-emitter currents by passing them through the base-emitter circuit, the emitter being in the common path.

Let the transistor be connected as shown in the figure and suppose for some reason the potential difference between base and emitter increases. This increase in potential will cause an increasing flow of electrons to the base-emitter path. This will cause the collector-emitter current to increase proportionately. As the collector current passes through the primary winding part of the output transformer shown in the figure as L_1, increasing voltage drop will appear across the winding L_1 and thus decrease the potential between the base and the emitter. Thus, in short, when the potential between the base and emitter increases that between collector and emitter decreases and vice versa, the two being in reverse phase. This is how the basic transistor amplifier stage operates, the varying potential across the base emitter being the input and corresponding varying potential across collector and emitter, the output. Now if we provide a suitable path, i.e. feedback from the output obtained at the collector to the base, it will produce degeneration of input at the base. This is called negative feedback.

Now if we consider the remaining primary winding L_2 of the output transformer, the increasing voltage across the winding L_1 will induce increasing voltage across the winding L_2. Though both these voltages increase simultaneously, they will be in opposite directions, i.e. if the extreme end of L_1 goes towards the positive, the induced voltage across L_2 will drive the extreme end of L_2 towards the negative. This means the centre-tapped output transformer



Circuit diagram of a transistorised beeper

can provide phase reversal. Thus, according to the circuit, the amplified output obtained at point *A* will be in the same phase with the input at the base. If the feedback is provided between these two points, it will give regenerative action to the amplifier to provide oscillations. This is called positive feedback.

Now for the connections. One of the terminals of the car battery, either positive or negative, is connected to the chassis. This is called earthing. Depending upon whether the positive or negative terminal is earthed, the car is called positive or negative earth type. The remaining terminal of the battery is connected to all the flashing lights through the flasher unit. Thus one of the terminals of our beeper unit will be connected to the car chassis. To make sure of the polarity, one can connect a DC voltmeter between the chassis and one of the terminals of the flasher. The connection which gives forward movement to the voltmeter pointer indicates the polarity, and the terminal on the flasher which gives periodically switching on and off voltage is the proper terminal.

You will need:

Transistor: AC 128 or 2 SB 66 or OC 74 or equivalent; *Transformer:* Output, push-pull type, primary matching with the transistor used and secondary matching with the loudspeaker; *Condenser:* Electrolytic — 100 Mfd — 12 volt or more — 1 pc; polyester or paper — 0·22 mfd 1 pc, 0·1 mfd 1 pc; *Potentiometer:* 100 K linear without switch; *Resistances:* All ½ watt: 2·2 K — 1 pc; 10 K — 1 pc; group board or lug stripes, solder, wire, knob, screws, etc.

Anil V. Borkar

Solutions to last month's Brain Teasers

Counter March: Square q, which black can reach by 20 equally short routes, and white by 21.

That's torn it: The bath towel and the face flannel should cost exactly 200 coupons.

Look at it this way: if you were to take up the third and first offers it would cost 420 coupons and you would have one of each article. Among these the hand towel and guest towel are worth 220, so the other two are worth 200.

Milky's Way: Fill pot from can. Empty pot into jug. Fill jug with water from tap. Fill pot from jug. Add remaining contents of pot to can. Fill can with water.

Both can and pot are now full with a mixture comprising two parts of milk to one of water.

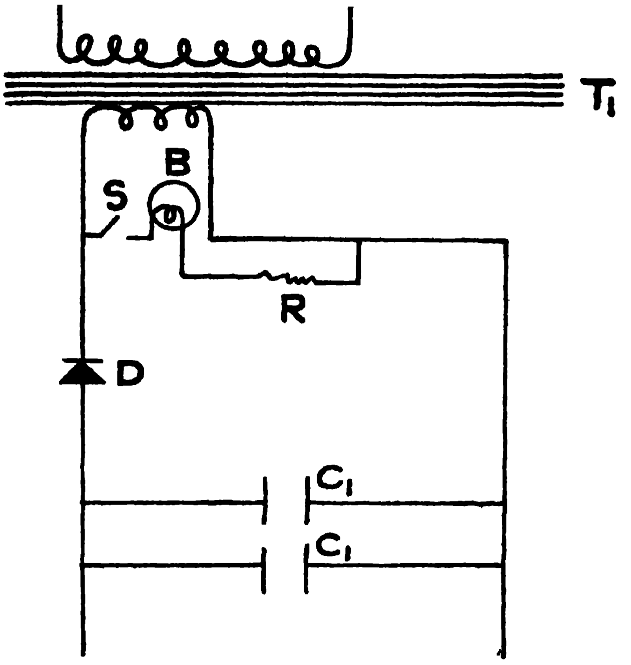
Trickle Battery Charger

IT usually happens in the morning when you are in a real hurry. The car just won't start: the battery is down and out. Don't you wish you had a battery charger, something that wouldn't cost a lot? Why not build one yourself?

This charger costs very little to make, less than Rs. 20. Of course, this trickle charger is not a fast worker — it will not recharge your auto battery immediately, because its output is only 0·5 amps. But this charger is designed to be hooked up to your car battery so that your battery can be charged all through the night. And rest assured: your battery will not be damaged in any way.

The working principle is essentially a half-wave rectifier circuit. As the circuit diagram shows, it consists of a transformer ' T ', a rectifier diode ' D ', two condensers, a pilot lamp, a normally open push-button switch and a resistor.

The main current is first reduced in voltage to 15 volts, then this current is rectified, i.e. changed from AC to DC so that it can now enter your battery. The capacitors are used to smooth out the voltage fluctuations due to half-wave rectification. The pilot bulb will light up when S is pressed, showing that the charger is working.



You will need:

1 T 15V — ·5 Amp. transformer; 1 S normally open S.P. switch; 1 B 2·5V ·3A bulb; 1 R 50 5 watt ; 1 D ; 2 C_1 1,000 mfd 15V working.

F. Rehman

The Building Stones of Chemical Analysis

Laboratory Chemicals are the building stones of chemical analysis; their quality and accuracy determine its success.
That's why in industries as well as research laboratories scientists insist on Laboratory Chemicals made by Sarabhai M. Chemicals.
These Laboratory Chemicals guarantee the utmost precision because they're made to international standards of purity and reliability.

Laboratory Chemicals
by

SARABHAI M. CHEMICALS LTD.
Post Box No. 80, Wadi Wadi, Baroda

Shilpi SM 11/70

FOR YOUNG READERS

JOURNEY TO THE MOON

THE SOVIET PROBES

Earth rising above the lunar horizon, photographed by Zond 7

WHILE the US has concentrated on landing man on the Moon, Soviet space scientists have been perfecting an automatic vehicle to rove the lunar surface. Their unmanned probes, with these mechanical robots, are obviously the forerunners of similar probes to Mars and Venus. The Soviet Moon programme began in 1959 with the Luna series the luniks.

Luna-1: First Moon probe. Launched on 2 January 1959. Its objective was to detect any magnetic fields or radioactivity in the vicinity of the Moon and to study meteoritic particles and the intensity of cosmic rays outside the magnetic field of the Earth. It passed within 5,000 to 6,000 km of the Moon and went into orbit round the Sun — thus becoming the first man-made planet.

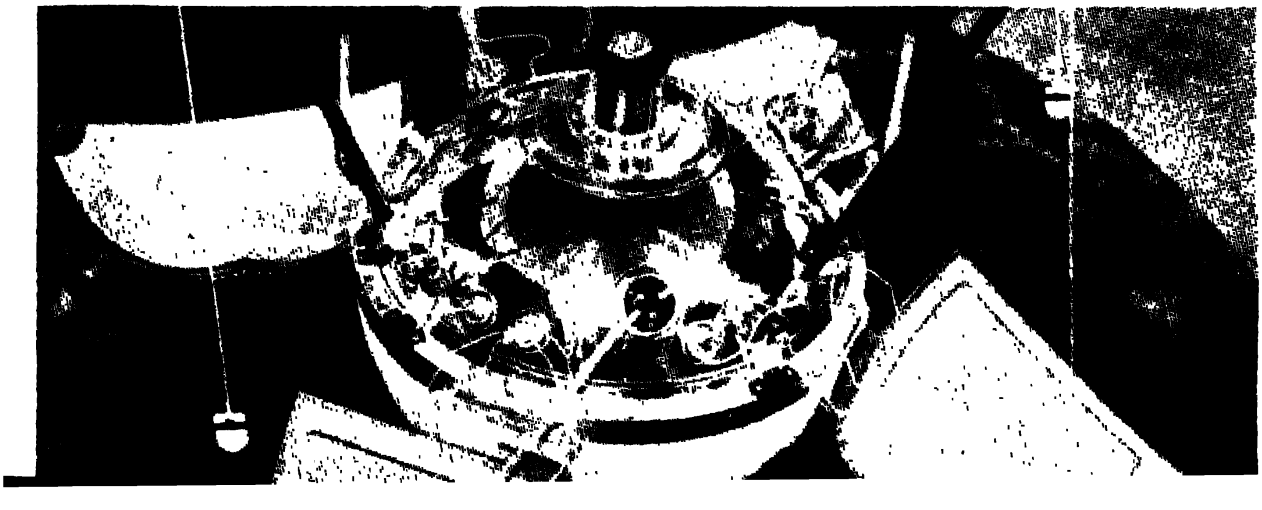
Luna-2: Launched on 12 September 1959. Landed in the area of the Seas of Clarity, Serenity and Vapours. Its purpose was to explore the magnetic fields of the Earth and Moon, the radiation belts around the Earth, interplanetary gas and meteoritic and cosmic particles. It established that there is no magnetic field or radiation belts around the Moon.

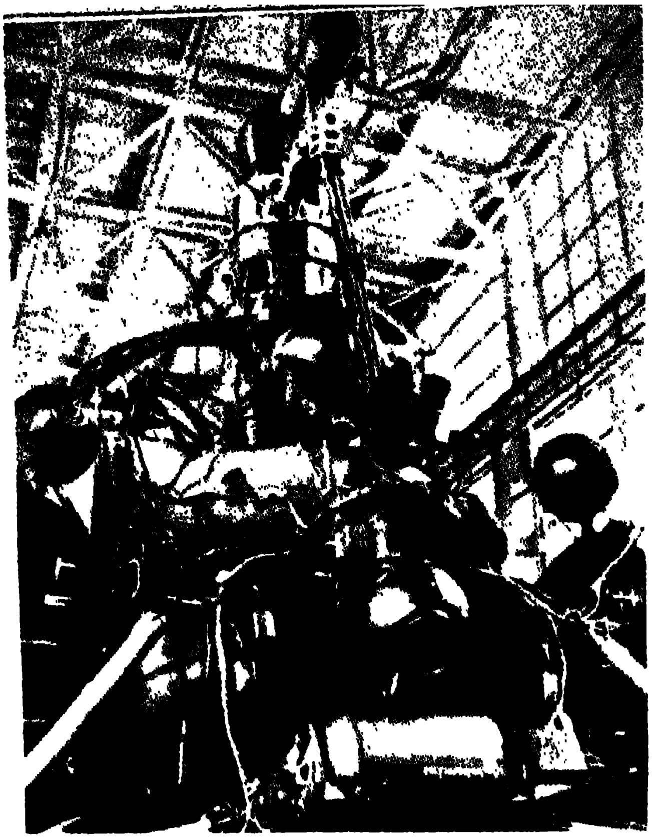
Luna-3: Launched on 4 October 1959. First space vehicle to fly around the Moon. Sent back 701 pictures of the far side of the Moon, some of whose craters were named (Sea of Moscow, Tsiolkovsky Crater, Sovetsky Crater). It became a man-made satellite of the Earth.

Luna-4: Launched on 2 April 1963. Soft landing attempt.

Luna-5: Launched on 9 May 1965. First in the series to attempt a soft landing on the Moon. Crash landed in the Sea of Clouds.

Luna 9 payload





Fully assembled Luna 16 readied for launch. Shrouded cylinder at centre is ascent stage instrument compartment. Dark sphere at top is the re-entry module for lunar samples

Luna-6: Launched on 8 June 1965. Missed the Moon by 1,60,000 km.

Luna-7: Launched on 4 October 1965. Crash landed in the Ocean of Storms.

Luna-8: Launched on 3 December 1965. Not much is known about its fate.

Luna-9: Launched on 31 January 1966. First Soviet spacecraft to soft land on the Moon at Oceanus Procellarium. Sent back television images of the lunar surface for 46 hours. Showed the lunar surface to be a sponge-like, rough-textured mass, scattered with individual fragments of various sizes and without a thick dust layer.

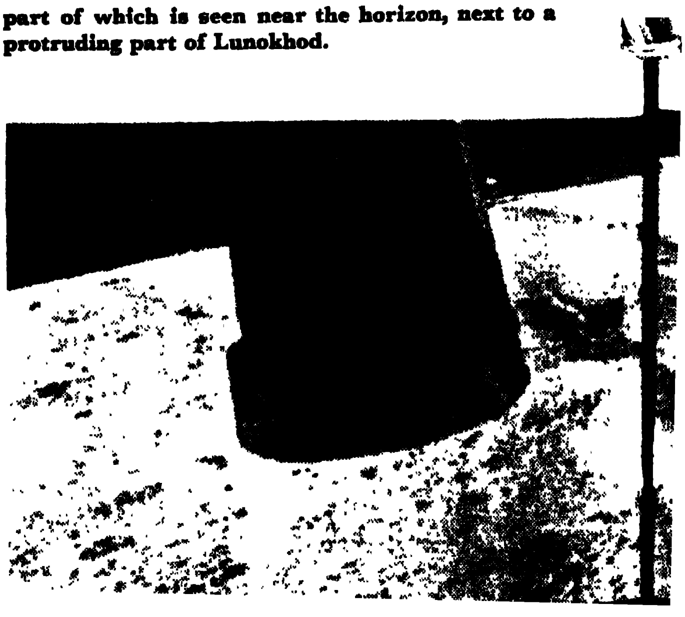
Luna-10: Launched on 31 March 1966. The first artificial selenoid, i.e. it went into lunar orbit. Completed 460 orbits before its power supply failed. Its information enabled scientists to draw preliminary conclusions on the composition of the lunar surface, radiation conditions and magnetic phenomena in the environs of the Moon, and also the density of meteorite substance and plasma near the Moon.

Luna-11: Launched on 24 August 1966. Second selenoid. It analysed the gamma and X-ray emissions of the lunar surface and investigated the concentration of meteorite showers and their distribution. It also observed long wave radio emissions from space.

Luna-12: Launched on 22 October 1966. Third selenoid. It conducted detailed measurements of the gamma radiation by the lunar surface, X-ray fluorescent radiation, corpuscular radiation and density of the micrometeoritic matter near the Moon. It also transmitted photographs of the Moon.

SOVIET MOONROVER: Luna 17 delivered the mobile Lunokhod-1 to the Moon soil on 17 November, 1970. Above is an artist's drawing of the moonrover leaving the landing stage.

The photograph below was made during TV cast from Lunokhod-1. One can see tracks made by the moonrover when it started its walk from Luna-17 part of which is seen near the horizon, next to a protruding part of Lunokhod.



Luna-13: Launched on 21 December 1966. Soft landed on the Moon in the Ocean of Storms. It had a soil meter and a measuring rod to test the firmness and density of the lunar soil. Showed the Moon surface layer (about 20–30 cm deep) to be close in properties to medium-density terrestrial soil. Also measured corpuscular space radiation. Showed that lunar surface reflects about 25 per cent of the particles which fall on it from space.

Photo at right shows a model of the eight-wheeled Lunokhod during tests on Earth

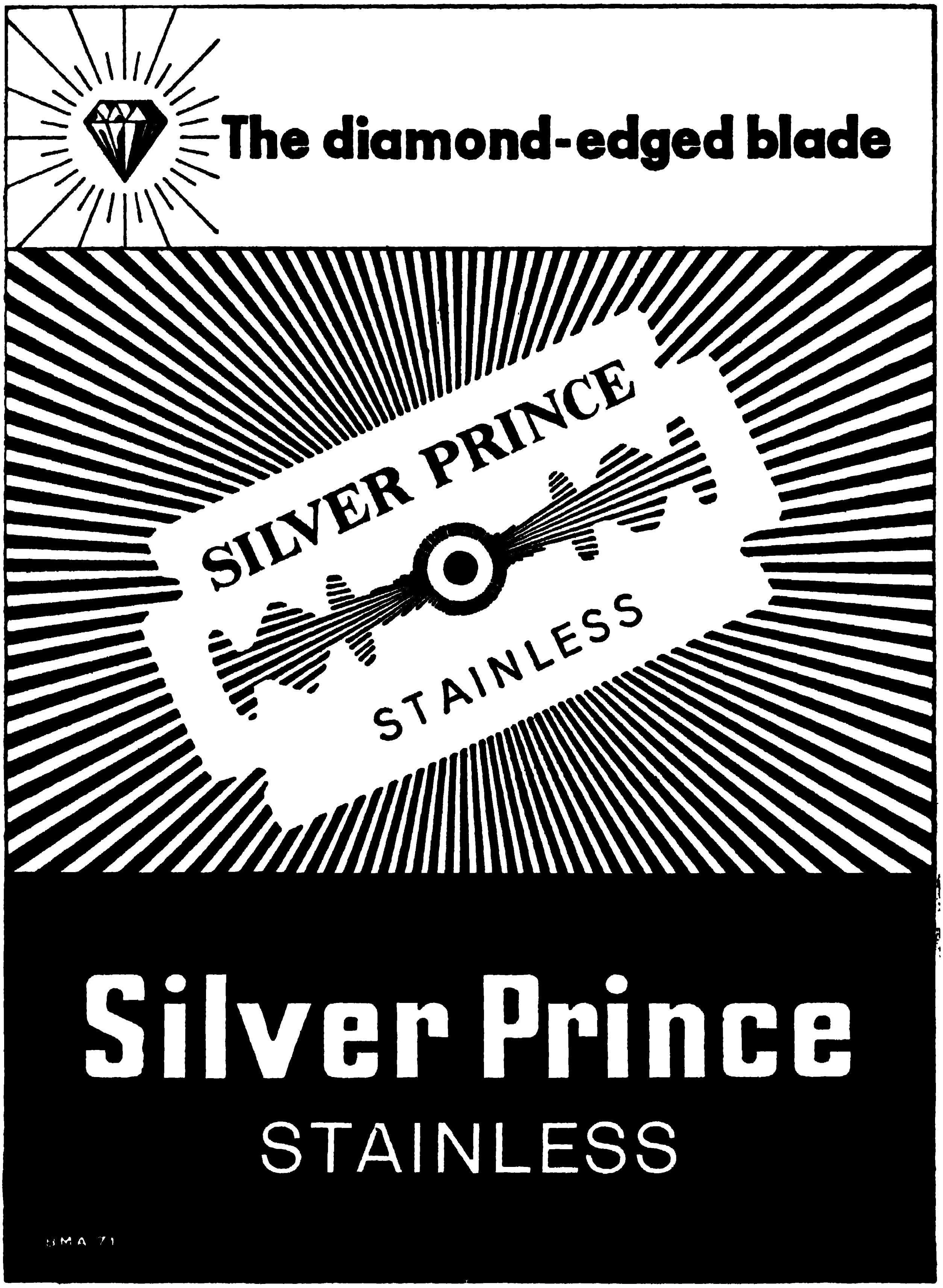
Luna-14: Not much is known about this probe.

Luna-15: Launched before Apollo 11. Crashed on lunar surface before Apollo 11 landed.

Luna-16: Launched on 12 September 1970. Soft landed on the Moon. Picked up soil samples and returned to Earth on 24 September 1970. It was the first reliable space robot and is the possible forerunner of robots to Venus and Mars.

Luna-17: Launched on 19 November 1970. Soft landed on the Moon. The first remote controlled Moon buggy, **Lunokhod-1,** roved the lunar surface. It was an 8-wheeled vehicle carrying apparatus to study the lunar surface and radio back its performance to Earth. It moved in the Sea of Rains and sampled lunar soil with its X-ray spectrometer. It measured galactic and cosmic radiation on the lunar surface. It was put to sleep in the 14-day long lunar night and later reawakened. Length 2·5 m, height 1·5 m.

Zond: The spacecraft in the Zond series are interplanetary probes. Of these **Zond-3** (launched in July 1965) took pictures of the reverse side of the Moon. **Zond-5** flew around the Moon and splashed down in the Indian ocean. **Zond-5** and **Zond-7** (launched in August 1969) carried four tortoises each. Tortoises were used instead of dogs (as in the earlier flights) because of their small size and ability to survive on small diets. Tests showed that their space trips had no harmful effects. **Zond-8** (launched in October 1970) too orbited the Moon.



The diamond-edged blade

Silver Prince
STAINLESS

SMA 71

MASCONS ON THE MOON

What are the "mascons" that have been discovered on the Moon?

NEWTON'S law of universal gravitation can be expressed as a very simple formula provided all the objects in the universe are each supposed to have their mass concentrated at a single point. If the objects are very far away, we can suppose this is so, but the closer the objects are to each other, the more we have to take into account the fact that actually their mass is spread over a large body.

Even so, the treatment remains quite simple provided (1) the object is a perfect sphere, and (2) its density is radially symmetrical. By " radially symmetrical " we mean that if an object is very dense at the centre, and is less and less dense the farther from the centre, the manner in which the density decreases is exactly the same no matter what direction we take from the centre. Even if there are quite sudden changes in density, that doesn't matter, provided these changes take place in just the same way in every possible direction from the centre.

Astronomical objects almost fulfil these requirements, if they are reasonably large. They are usually close to spherical in shape, and their density is almost radially symmetrical. Of course, we do have to allow for small deviations when objects are particularly close to each other. In studying the gavitational effects between the Moon and the Earth, we have to allow for the fact that the Earth is not a perfect sphere but has an equatorial bulge. The extra matter in the bulge produces a tiny gravitational effect of its own that must be taken into account.

Several years ago, the United States put several space vehicles (lunar orbiters) into orbit about the Moon. Knowing the Moon's size and shape in detail, the rocket experts were sure they could calculate exactly how quickly the vehicles would travel about the Moon. To their surprise, however, they found that the vehicles moved just a trifle too quickly in some parts of the orbit.

The orbits were observed in detail, and it turned out that the vehicles speeded up very slightly when they passed over the large lunar *maria*, the flat regions with few craters. This could only be because the Moon was not quite radially symmetric in density. There must be extra mass concentrations in those *maria* which produced an additional gravitational effect that had not been allowed for. Astronomers began to speak of " mass concentrations " or, in abbreviated form, " mascons."

What are these mascons?

Two theories have arisen. Some astronomers think the *maria* are extra-huge craters produced by the collision of particularly large meteorites with the Moon. These meteorites might have buried themselves under the surface of the *maria* and would still be there. They would be largely iron in composition, perhaps, and much denser than the Moon's normal surface. They would thus represent an abnormally high concentration of mass.

A second theory is that during the Moon's early history, the *maria* were really seas of water. Dense sediments were laid down before the water evaporated off into space and these would still be there, accounting for the extra concentration of mass.

Further exploration of the Moon's surface ought to determine which of these theories (if either) is correct, and this might further tell us a great deal about the Moon's (and Earth's) early history.

Isaac Asimov

" What makes you think we didn't catch it in time ?"

SCIENCE ON STAMPS

Rupin Patel

PANGOLIN: These scaly anteaters are the armoured mammals of the order Pholidota. The word pangolin is derived from Malayan, meaning 'roller'. The pangolin has the defensive habit of rolling itself into ball when threatened by danger. As a general rule, it is an non-aggressive animal, confusing its attacker by its rolling action.

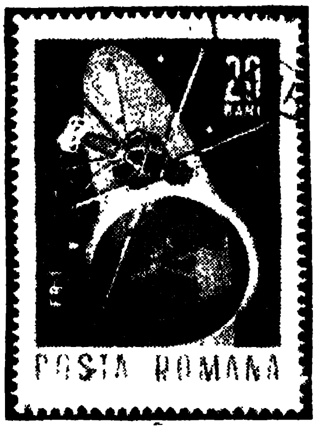
It is generally found in tropical Asia and Africa. Its length varies from 0·3 to 1 metre, exclusive of its tail. The tail may be shorter than the body or twice the length of the body. It has short legs, a long and wormlike tongue, but no teeth. Its body, with the exception of the belly, is covered with broad, overlapping, yellowish-brown, horny scales.

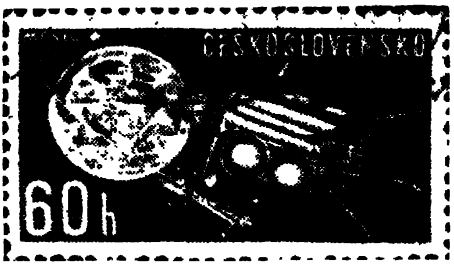
All species are nocturnal insect eaters. They use their covered claws to rip open ant or termite nests and the long tongue searches out their food.

Not much is known about its reproductive cycle and life span. Apparently one young is born at a time and is carried by the mother for some time. It is estimated to live a dozen years or more.

Several distinct types are usually grouped in a single genus, *Manis.*

10sh Kenyan stamp (below). One of 14 in a definitive series issued on 12 December 1966.





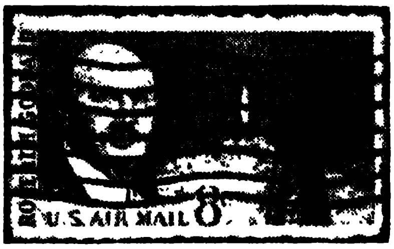
SPACE

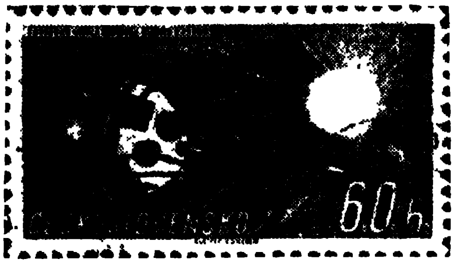
20b Rumanian stamp (left). Ultramarine, black and red colour. Depicting FR.1 (French) satellite. Issued on 25 June 1966 to honour international achievements in space.

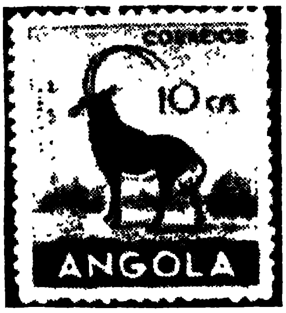
8c US stamp (below). Blue, red and blister colour. Issued on 5 October 1964 to honour Dr. Robert H. Goddard (1882-1945), physicist and pioneer rocket researcher.

60h Czechoslovakian stamp (above). Dark green and yellow colour. Issued on 25 April 1963. Depicting moon landing spacecraft.

60h Czechoslovakian stamp (below). Violet and buff colour. Depicting Sputnik I. Issued on 6 March 1961 to publicise Soviet space achievements. From a set of 6 stamps.





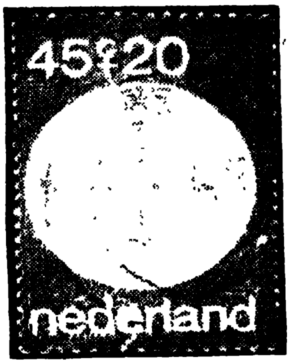


SABLE ANTELOPES. Family — Bovidae. Genus — Hippotragus. Specie — *H. niger.* Sable antelopes are ruminants (animals which chew the cud).

They are peaceful and timid but agile and fleet animals. The large and handsome South African antelope is of a black or dark colour. This hoofed animal has stout, thickly ringed, hollow horns, rising vertically from a ridge over the eyes and then sweeping backwards in a curve. They are permanent horns, not renewed every year like deer's horns. Forest-clad highlands are the antelope's favourite habitat. They move in groups of 10 to 20.

10c Angolan stamp (left). Issued on 5 August 1952. Multicoloured.

10c Kenyan stamp (below). Black and yellow-green colour. Issued on 12 December 1966 as part of a definitive series.

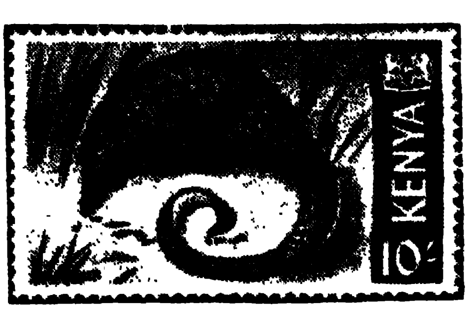


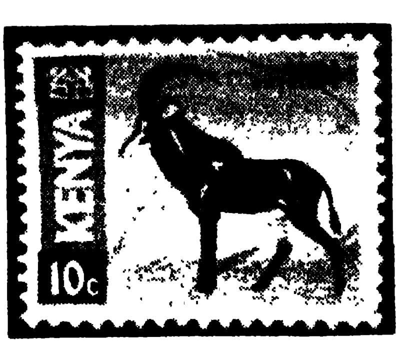
COMPUTER STAMPS: The designing of stamps is a specialised job. The Netherlands has initiated an entirely new concept in design work. On 7 April 1970, it brought out a set of five stamps for the Cultural, Health and Social Welfare Funds. A surcharge is collected over and above the face value of the stamps, which goes towards charitable work.

The stamps depict circles, squares, parallel planes in cubes, overlapping scales, concentric circles in transition, and spirals.

These stamps are unique in that all of them were designed by a computer. Data was fed into the computer by R. Oxenaar and the result was five different abstract designs.

45c + 20 Netherlands stamp (above). Silver grey colour. Depicting spirals.

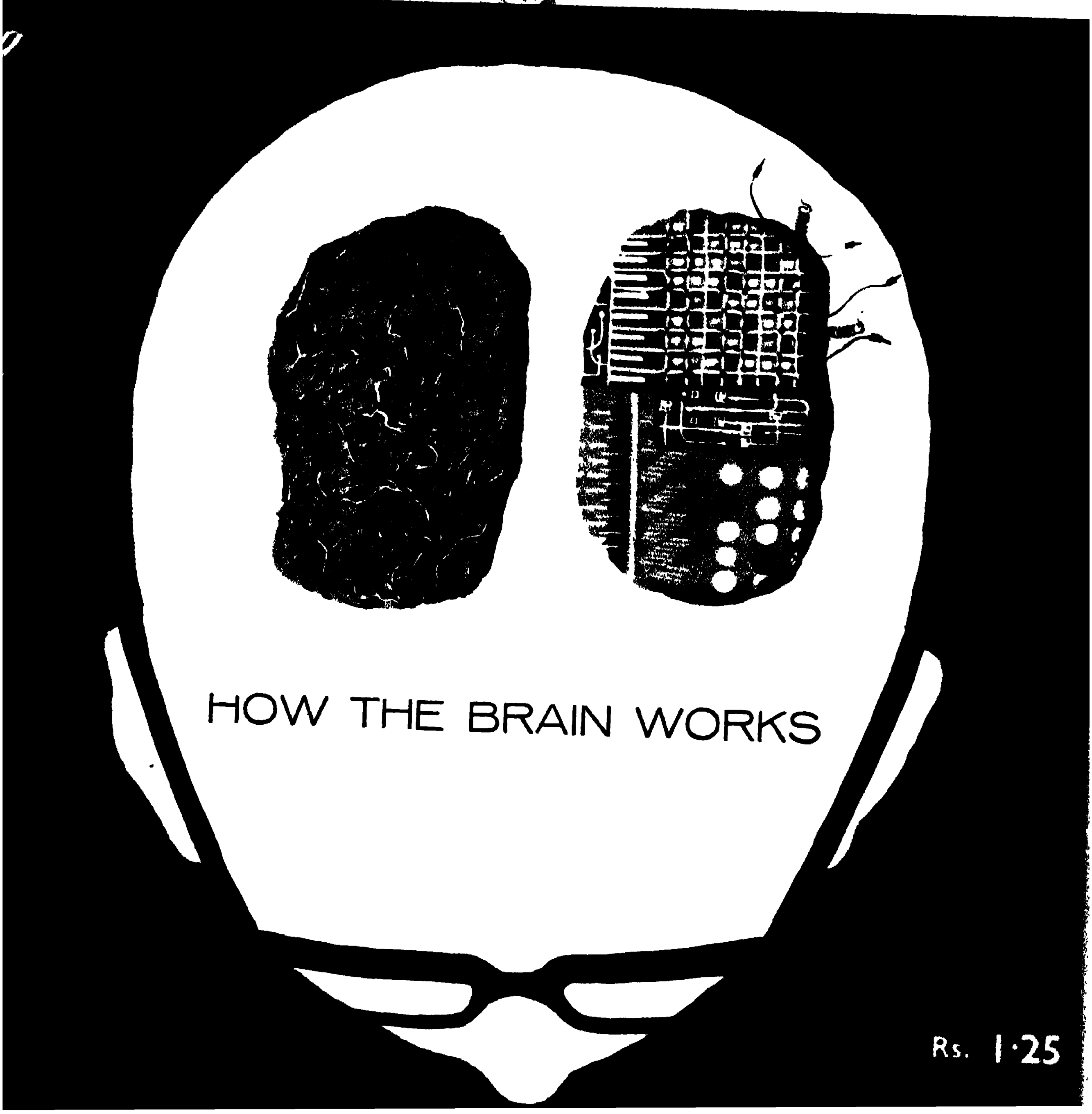




SCIENCE TODA

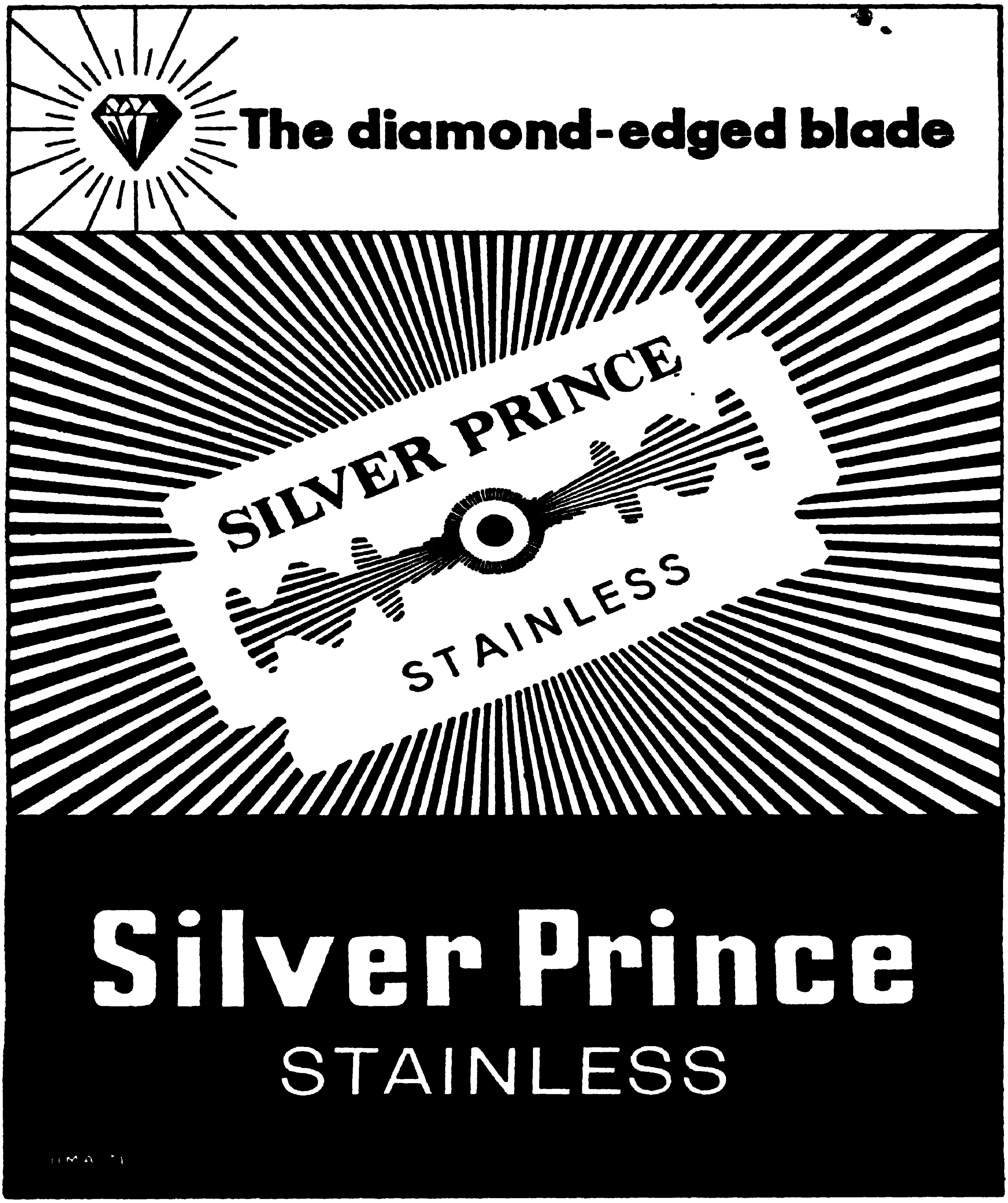
FOR EVERYM

LIBRARY



HOW THE BRAIN WORKS

Rs. 1·25


The diamond-edged blade
SILVER PRINCE
STAINLESS
Silver Prince
STAINLESS

Vol. 5 No. 10 April 1971

SCIENCE TODAY

ARTICLES

CAN MACHINES SEE? by S. Ramani 11

The eyes see. But it is the brain that processes the visual information to make it intelligible. The process is very complex and is the least understood activity of the brain. Computer scientists are now probing for the clue by duplicating the brain's visual activity in a simple " seeing machine "

EINSTEIN'S "FIRST" PAPER by Jagdish Mehra 22

When did Einstein take the first step towards his famous concepts? When he was fifteen years old? The answer is probably, yes, according to the author who discovered this " first " paper

CONDITIONS FAVOURING MAJOR ADVANCES IN SOCIAL SCIENCE by Karl W. Deutsch, John Platt & Dieter Senghaas 34

Does creative success in the social sciences depend on environmental group conditions? Are these advances cumulative? Who achieved the breakthroughs? Where were they achieved? How? When? Why? The questions multiply. The answers may lie in this analysis of 62 major advances since 1900

FEATURES

About the Authors 4
Letters 4
Awards & Appointments 6
Science Shapes Life 7
Round-up of Research 29
Blurs & Bright Spots 33
Apollo 14—The Long Walk 48
The Animal World (Vultures) 52
Brain Teasers 55
Books 57
For Young Readers (Sound Film) 59
How Does It Work? 61
Science on Stamps 63

COVER

A major activity of the brain is processing what the eyes see. Duplicate its principal parts, and you may have a " seeing machine "
(Painting by Shabbir Diwan)

Annual Subscription Rs. 12·50
Single copy: Rs. 1·25; 10p

Editor
Surendr Jha

Printed and published for the proprietors Bennett, Coleman & Co., Ltd., by Pyarelal Sah at
Times of India Press, Bombay, India. Delhi Office: 7, Bahadur Shah Zaffar Marg, New Delhi
Calcutta Office: 13-1 and 13-2, Government Place East; London Office: 3, Albemarle Street

ABOUT THE AUTHORS

S. RAMANI (*Can Machines See ?*) studied electrical engineering at Madras University and the Indian Institute of Technology, Bombay, before joining the Computer Group of the TIFR, Bombay, in 1964. In 1969, he obtained his doctorate from the IIT.

His present field of work is artificial intelligence or how to induce computers to carry out intelligent tasks.

●●

JAGDISH MEHRA (*Albert Einstein's "First" Paper*) is with the Center for Particle Theory, University of Texas at Austin, Austin, Texas 78712 (USA). Before joining Texas University, Dr. Mehra was the Director of Science Research Associates (a subsidy of IBM) in Chicago. Dr. Mehra's research interest is in those historical aspects of physics which throw light on modern developments. He has also done considerable work in the field of public understanding of science in underdeveloped countries.

●●

Dr. KARL W. DEUTSCH (*Conditions Favouring Major Advances in Social Science*) is professor of government at Harvard University, Massachusetts, USA.

Dr. JOHN PLATT is associate director of the Mental Health Research Institute University of Michigan, USA.

Dr. DIETER SENGHAAS is assistant professor at Goethe University, Frankfurt, W. Germany.

LETTERS

Focus

In his "Focus on Indian Science and Technology" (SCIENCE TODAY, January 1971) Prof. Narasimhan has brought out the following points:

(*i*) Science Policy Resolution of 1958 is a statement of Government's faith and its commitment to foster science and technology. It is not an action document — merely a credo — and hence the question of its implementation does not arise.

(*ii*) For the successful utilisation of science and technology, i e putting science to work — it is necessary to evolve both long and short-term technological profiles.

(*iii*) Lastly, what should be the appropriate machinery for delineating the objectives of science and technology? Should the Planning Commission do this or COST?

It appears to us that for Prof. Narasimhan science policy is synonymous with science plan, i e action programme. Science policy is a statement that provides a basis for national or international decisions influencing the size, institutional structure and resources in relation especially to its application and public consequences. It thus attempts to coordinate the intentions of Government about science with those of the economic and social sectors. Viewed thus, science policy is the basis for further action. It sets out the goals and objectives for science and technology in broad terms on the national level. For reasons of flexibility, and the nature of science and technology being what it is, this policy statement has to be couched in general and ambivalent terms. The task of translating these objectives into action programmes is actually that of the major science organisations in the country in particular and the scientific community in general.

As an example we can cite the case of the Government's nuclear policy. Here the emphasis is on the development of nuclear energy for peaceful purposes. This policy again is a non-action statement, and expresses the Government's commitment to exploit nuclear energy for peaceful purposes alone. The task of implementing it and translating it into action programmes belongs either to the Department of Atomic Energy or the Atomic Energy Commission. So is the case with the overall science policy. Success and failure of a science policy depends on the seriousness and depth with which programmes of action are formulated and integrated with other development programmes. It also depends on the existing size and infrastructure of scientific research in the country. No ambitious programmes of scientific development and science utilisation can be undertaken unless science has grown to a minimum threshold. It would be a fallacy to think that one can put science to work without achieving this threshold. Finally, this threshold is a moving and dynamic one and this is the inner logic of the growth of science.

Secondly, Prof. Narasimhan feels that it is essential to develop both long and short-term profiles of technology.

According to him, this is a prerequisite for the utilisation of science. If this is lacking, science would grow in a vacuum as has happened in the past. Science and technology development programmes must have a purpose. Mere imitation of the western developments on the technological front would create a crisis of social values. Technological programmes must arise out of social needs and must be directed towards solving these problems. The advantage of such an approach is that the technologies thus developed will be absorbed smoothly and would create less social tensions.

Further, this aspect is particularly relevant to developing and underdeveloped societies. These societies are deficient in resources, both capital and human. In addition, they lack the tradition of " modern science ". Hence emphasis on technological profile alone leads to lopsided priorities. It can be seen that in these countries there is a tendency to deploy the scarce scientific resources on working in fashionable areas of science, ie frontiers of science and the immediate problems of the country go unnoticed. If, however, the social and economic needs were to be the only guiding factors, then science would become more relevant to society. These societies have to deliberate more seriously on the questions: what sort of science do we want? How much of it do we want? Who should do it? How should they and their activities be controlled? But the more significant and basic question underlying all this is: *what sort of society do we want?* Science and technology transform and alter social relations and hence technologies must not be projected in a futuristic vacuum.

Lastly, Prof. Narasimhan raises the important question of who should work out the science plan of the country and ends on a satirical note. We feel this task cannot be handled by the Planning Commission. This must be the responsibility of COST with the active cooperation and participation of scientists both inside and outside the Government. We feel that the charter of COST needs to be made more specific and COST must have executive responsibility for science in addition to its advisory role. The basic function of COST should be as under:

(*i*) To coordinate research efforts in various agencies, (eg the CSIR, ICAR, ICMR and the DAE) and lay down priorities which are in consonance with the social and economic objectives of the country,

(*ii*) To prepare a consolidated budget of science to be presented to Parliament every year,

(*iii*) To prepare a science report which would give an account of the status of science in the country and also outline the long-term prospects for science and the related short-term tasks in consonance with social and economic goals of the nation,

(*iv*) To analyse and develop the parameters for a science policy and to undertake studies on various social, economic and organisational aspects of science in the country,

(*v*) To prepare long-range programmes designed to solve the scientific and technological problems of the country including capital and manpower requirements,

(*vi*) To consider and recommend measures for the effective implementation of governmental policies concerning the administration and conduct of governmental programmes in science and technology,

(*vii*) To scrutinise, supervise and implement multilateral and bilateral agreements in the fields of science and technology so as to work out international collaboration policies.

K. D. Sharma

S. Malik

Research, Survey and Planning Organisation, CSIR,
New Delhi

Aluminium Conductors

In his otherwise instructive and informative article "Aluminium Conductors " (SCIENCE TODAY, December 1970), Dr. Rajendra Kumar has made a fundamental error in stating that power transmission is most economical when it operates at the highest voltage because " the load capacity of a line varies approximately with the square of the operating voltage ".

We have learnt that power (W) is equal to the product of voltage (E) and the current (I), that is to say $W = EI$.

The current-carrying capacity of a line depends upon its size (cross-sectional area) and the temperature the conductor can be allowed to achieve, which depends upon the character of the surroundings of the conductor. Thus, irrespective of the line voltage, the maximum current 'I' under similar sets of conditions can be the same. Therefore, if the line voltage is doubled, the load which can be carried by the line will only be doubled and not squared.

Dr. Kumar should have suggested that for the same load on a line, if the voltage is doubled, the current is halved and the power loss in the line for the same load is one-fourth of what it is in the first case. (Line loss is I^2R. Line capacity is EI.) Doubling the voltage doubles the line capacity and line loss remains the same but is now for double the line load.

The determination of the economical line voltage depends upon various technical and capital cost aspects and is an involved subject, not so oversimplified as Dr. Kumar has attempted to suggest.

B. V. Malani

Bombay

[DR. RAJENDRA KUMAR WRITES : There is no doubt that the determination of the economical line voltage is an involved process. The article, however, was essentially concerned with aluminium as a conductor material and the intricacies of electrical transmission and distribution were mentioned only to emphasise that the loading capacity of a conductor is a characteristic of the material as well. It has been empirically observed that the loading capacity of the line for most economical transmission varies approximately with the square of the operating voltage (see *Aluminium Design & Application Vol. 2, American Society of Metals, 1967*).]

AWARDS & APPOINTMENTS

Dr. Hargobind Khorana, the Indian-born Nobel Laureate, now settled in the United States, has been elected honorary member of the USSR Academy of Sciences. He is among 15 distinguished world scientists to receive the honour this year.

* * *

Dr. J. K. Mody of the Cancer Research Institute, Bombay, has been awarded a research fellowship by the National Cancer Association of South Africa.

* * *

A Regional Research Laboratory to look after the development needs of UP, Bihar, Madhya Pradesh and Rajasthan will be established soon. A working group under the chairmanship of Mr. K. C. Pant, Vice-President of the Council of Scientific and Industrial Research, has been set up to work out the scope and functions of the laboratory. The members are : Dr. Brahm Prakash, Director, Metallurgy Group, Bhabha Atomic Research Centre, Dr. V. B. Chipalkatti, Director, Shri Ram Institute of Industrial Research, and Mr. L. Kumar, Adviser, Union Ministry of Petroleum and Chemicals.

In the forthcoming issues . . .

HEATSTROKES

LOCUSTS — THE FLYING SCOURGE

PULSARS TO COLLAPSARS—FERMENT IN THE HEAVENS

BIOCHEMISTRY OF MENTAL DISORDERS

THE WILY FOX (ANIMAL WORLD)

Guaranteed Reagents (G.R.)

pro analysi

...for utmost precision in research and analysis

Specific preparations are available for individual requirements. Write to:

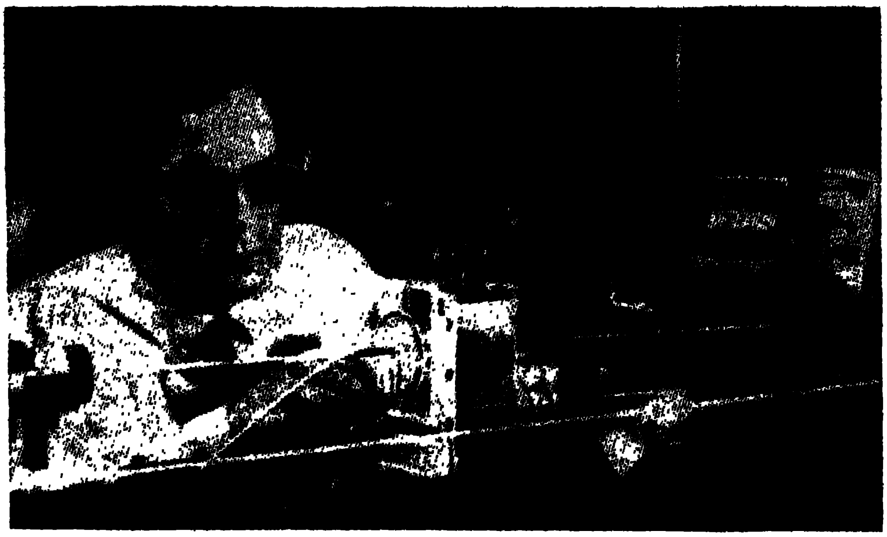
SARABHAI M. CHEMICALS
PRIVATE LIMITED
Post Box No. 80, Wadi Wadi, Baroda

Shilpi SM 60/70

SCIENCE SHAPES LIFE

CIGARETTES SANS NICOTINE

Polish scientists have finally achieved what many scientists have been trying to do for years — produce a cigarette without nicotine. The Polish scientists spent several years growing various strains of American virginia tobacco under test conditions. The tobacco, after harvesting and treatment, contains a mere 0.1 per cent of nicotine. Cigarettes made from this tobacco have similar qualities of taste and smell as the best normal, mild cigarettes, claim the scientists.



FASTER THAN THE FASTEST

There is a laser beam that can transmit information the equivalent of 200 books in one second. That's fast. Real fast. An optical modulator, a crystal device, impresses a laser beam with a billion bits of information (a gigabit) per second, four times the capacity of previous systems. This experimental communications system has been devised by Gerald White of Bell Laboratories, USA.

BON VOYAGE

Sailors will breathe a sigh of relief when Digiplot, a new computing radar, is installed on ships. Safe at last. For it provides unattended radar watch-keeping and, hence, eliminates the danger of collisions at sea. The system, said to be the most significant contribution to marine technology since the invention of radar, is the first of its kind in the world.

Developed by a British firm, Digiplot analyses all echoes picked up by a ship's radar and automatically tracks and plots up to 40 of the most threatening objects within 27 km. When danger approaches, an alarm is automatically set off in ample time for the ship to make the necessary course corrections. Navies of the world should find this device especially interesting because of the danger of sea collisions during naval exercises.

A THINKING ROBOT

A robot with a 'brain' and an 'eye' — that's the latest in robotics. A Japanese firm has built an industrial robot that can 'look' at a blueprint, 'decide' how a process should be carried out and then go a step further to assemble an object.

The robot has a large controlling computer for a brain. Its eyes are two Vidicon cameras, its hands a handling device which can perform seven basic motions, including forward and back, left and right, and up and down.

The eye can break an image into 76,800 parts and identify them individually in 32 ways according to brightness. This is data for the computer which then controls the manual assembly with the help of other memorised data. Such robots, having intelligence, can open the way for unmanned machinery plants in the future.

SHATTERPROOF LAMP

Edison's invention has come a long way. A British industrial company has now come out with a shatterproof electric lamp. This lamp will prove especially useful in industry or commerce where the fragments from a broken bulb could contaminate food and materials.

A special coating of silicone rubber gives the bulb its shatterproof qualities. The coating, which holds glass particles together in the event of breakages, is of course translucent and does not noticeably reduce the amount of light emitted. The silicone rubber does not cause any appreciable heat build-up in the lamp; its surface area is sufficient to dissipate heat in the ordinary way. At present lamps of 100 watts in 200/250 volts rating have been manufactured.

Originally developed for the food industry and similar environments, this lamp also has applications in breweries, restaurants, as inspection lamps in garages, bedlamps in hospitals and in schools.

PAINTING ALUMINIUM

And now three Japanese firms have jointly come out with a new painting method capable of imparting any colour to products of aluminium — at a very nominal cost.

It is the same process as electroplating, using a combination of three methods — the electro-coating method, the water-soluble acrylic resin production method, and the water-dispersable pigment and resinous polymer-combined pigment production method.

The aluminium object to be painted is positioned as the anode. The cathode is the pigment. The process produces a completely uniform coating. It is a good, transparent-looking quality film coating which is far more resistant to weather and corrosion than conventional, coloured aluminium coating. The cost, about 30 per cent less than for conventional methods, works out to about Rs. 10 per sq metre.

A RESURRECTED VOICE

For long, medicine has been helpless in cases of loss of voice. Glycerine has recently been reported to restore voice. Now a Russian apparatus also makes a similar claim.

The mechanism, developed by a team of doctors and engineers, consists of an electrovibration unit with a plunger which affects the membrane. It is powered by a 5V rechargeable battery. A push button sets the mechanism working when the person wishes to say something. One charging of the battery, it is said, lasts a full day. Recharging is done by plugging into the AC mains supply. A report says that patients have found no difficulty in using the apparatus and all avail themselves fully of their new artificial voices.

Meanwhile, a hearing aid which will be implanted entirely inside the ear is under test in the US. The implanted device stimulates the inner ear instead of the outer ear as in most of the conventional methods. The device consists of an oscillator, a tiny microphone placed in the ear canal, and a battery rechargeable through the skin.

TREATMENT FOR BURNS

Severe burn cases cause infection and ugly scars in the victim. A new method of treatment which is claimed to avoid these was reported by a Yugoslav, Dr. Zora Janzekovic, at a recent international conference on research in burns at Prague, Czechoslovakia.

In the new method, all the layers of burnt tissues are peeled off till the healthy tissue is reached and then healthy skin is grafted. But this has to be done between the third and the fifth day of the accident. Most of the present cases of infection are due to delayed treatment, says Dr. Janzekovic. The new method prevents infection and reduces the period of hospitalisation.

FLOATING AIRPORTS

The extent to which a technological society will go! The Japanese are now building an airport on water! The difficulties of land acquisition, air pollution, noise pollution and overcrowding at Osaka International Airport have led them to study the feasibility of such a scheme.

The airport will be situated in Osaka Bay. It will have four 4,000-metre and four 3,200-metre runways. It will occupy an area of 2,000 hectares of land — over twice the area of the New Tokyo International Airport.

As land filling methods in the deep sea are prohibitively costly, and as a floating airport would encounter difficulties in anchorage and are vulnerable to wave forces, the Japanese have decided on a combined concept — an airport stabilised by mooring lines as well as by piles driven into the sea bottom. The access system will comprise a submarine tube to accommodate a lightweight monorail-type mass transit unit adapted for a shuttle service.

INTEGRATED CIRCUITS

At present, optical methods are used to make microcircuits. Large patterns are drawn and then progressively reduced to form the masks through which several hundred circuits can be produced on a slice of silicon only 5 cm in diameter. But optical methods are reaching their limits of possible accuracy.

A British firm has now developed a highly precise, stereoscan scanning electron microscope which promises a revolution in the manufacture of semi-conductor components and microcircuits. The microscope

WHAT HAPPENS IN NERVES?

The nervous system in man is a complex network of thread-like nerve fibres which transmit nervous messages in the form of minute electrical impulses. But when these messages pass from one nerve to another, they travel not as electric impulses but as small packets of a substance called acetylcholine.

Sir Bernard Katz, Chief of the Department of Biophysics at University College, London, earned a Nobel Prize in medicine last year when he discovered the way in which this substance is released from nerve endings. Now, Dr. R. Miledi, Dr. P. Molinoff and Dr. L. T. Potter, also of the Department of Biophysics, have identified the 'receptor' on the second nerve fibre to which the acetycholine becomes attached.

Dr. Miledi and his colleagues used, of all things, a strange substance found in the venom of a poisonous snake from Taiwan to achieve this breakthrough in understanding the working of the nervous system. This component of snake venom, bungarotoxin, interferes with the transmission of acetylcholine from one nerve to another. It does this by binding to the same site in the nerve junction to which the acetylcholine molecules normally travel. Once bungarotoxin binds, the union becomes firm. Dr. Miledi and his colleagues, therefore, labelled the bungarotoxin with radioactivity. They treated nervous tissue taken from the electric eel with this radioactive substance. (The electric eel was specifically chosen as it is rich in such receptor sites.) They were thus able to locate the receptor by tracing the radioactive bungarotoxin. The receptor site seems to be a complex of small protein units firmly bound to the nerve membrane.

The discovery, hailed by scientists and psychologists, will help considerably in understanding the nervous system and in resolving the deeply entrenched argument on the molecular basis of learning and behaviour. The next step for scientists will be to discover how acetylcholine molecules generate intelligible impulses in the next nerve fibre.

magnifies the structure of materials for examination. This enables a greater accuracy down to still smaller dimensions. An added advantage is that the scanning can be controlled by computer — and it is far more accurate and speedier than optical methods.

THIN MEN ARE WITHDRAWN

Get fat to be happy, the thin are nervous. Athletic types are aggressive. These are common associations between physical shape and personality. But to relate them scientifically has been a difficult task.

William Sheldon first divided body types into ectomorphs, mesomorphs and endomorphs — in simpler language, into thin, muscular and fat types. But he didn't succeed in relating these types to personality.

Dr. Juan B. Cortes of Georgetown University and Florence M. Gatti of Harvard, USA, have now shown some sp[illegible]c type relationships. Their [illegible]n ents involved better defined [illegible]ables and more rigorous contro[illegible]

[illegible]nificantly connected body type [illegible] a very reliable measurement of personality factor — the need or drive for achievement. They tested 100 delinquent and 100 non-delinquent boys in their late teens. Their conclusion: the need for achievement was stronger in mesomorphs than in other types. Ectomorphs were significantly lower in the scale.

Further self-description tests on college students and felons revealed more interesting connections. Endomorphs emerged socialising, mesomorphs aggressive and ectomorphs withdrawn.

A MOMENT IN TIME

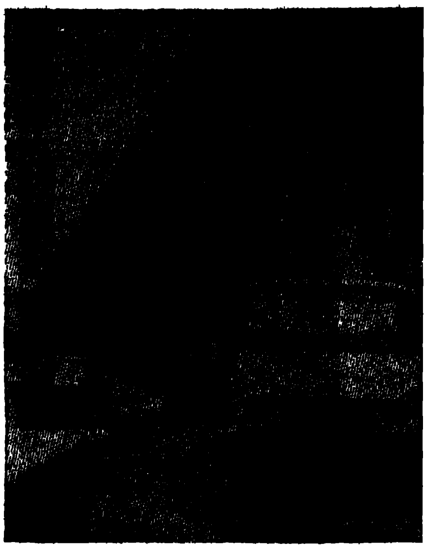
A second is a short time. So are fractions of a second. But when calculations involve microfractions of a second, the imagination boggles. Yet two scientists, W. M. Gibson of Bell Laboratories, USA, and K. O. Nielson of Arhus University, Denmark, have developed a new technique for measuring events lasting only 0.000,000,000,000,000,01 (10^{-17}) of a second. In this time, light would travel four-millionth of a centimetre. It represents the time taken for a neptunium nucleus to disintegrate. Till now, the shortest event recorded, also a nuclear lifetime, was 1,000 times longer than the neptunium lifetime. Neptunium nuclei disintegrate soon after they are formed, some even before leaving, or recoiling from, their original position in a uranium oxide crystal on bombardment with high energy protons.

In the experiment, a sheet of clear plastic is placed about 30 cm from the crystal. Fission fragments strike the plastic and leave marks (which are visible after chemical treatment) that form a ' blocking pattern '. The blocking patterns of a control crystal (which has no recoiled nuclei) and of the experimental crystal (which has a few recoiled nuclei emitted along the direction of an atomic row in the control) are the key to determining the average recoil distance. The lifetime of the nucleus is then measured.

This technique will eventually help scientists in understanding more completely nuclear reactions and the basic structure of matter.

THE WALL OF SILENCE

Put up a wall and keep the noise down. That is what they are doing in Frankfurt, Germany. A parabolic, 15-metre-high, concrete wall, designed by acoustics experts, is going up in sections 3 metres high by 8 metres long. It will help fight noise pollution from the nearby airport. The cost — Rs. 60,75,000 so far.



NO MUSIC BOX THIS TIME

The Chinese have done it again. They launched their second satellite into space on 4 March 1971 from the Shwang-chengtze space exploration centre in North-west China.

The satellite, of an undisclosed size, is orbiting the Earth every 106 minutes with an apogee of 1,800 km and a perigee of 269 km.

The satellite launching has been interpreted as further confirmation towards the development of an intercontinental ballistic missile carrying a thermonuclear warhead. The booster used could be either the medium-range ballistic missile booster or a test booster for an intercontinental missile. The general assumption is that China is using an improved version of its MRBM — a rocket with a 1,600 km range.

The Chinese information media did not disclose any information on the second satellite. This could mean the satellite is a more sophisticated one, with more serious tasks, than the " music box " orbited last year. The first satellite kept chiming the words " The East is red ".

ON SALE — CLEAN ENVIRONMENT

A Houston, USA, department store has started selling clean environment — a plastic geodesic dome which can cover an area of one acre. The air inside is kept clean and cool at 22·3°C; airborne pollutants float over the dome. But the dome is made of material which will let in the Sun's rays.

DISCOVER A FOUNTAIN OF FLAVOUR
Fanta
Fanta
Fanta
FANTA ORANGE TASTES SO GOOD, IT'S FUN TO BE THIRSTY.
FANTA IS A PRODUCT OF THE COCA-COLA COMPANY
CMCF-2-203

The information that the eyes collect about the world is processed in a very complex way by the brain before it becomes useful. This processing is one of the little understood activities of the brain. One way of learning to appreciate the complexity of this process and to understand something of its nature is to attempt duplicating some simple version of it in the laboratory

CAN MACHINES SEE?

S. RAMANI

CAN we build a machine which can see? Many people have tried, often with some practical applications in view. One attempt that has been crowned with success resulted in what are called "Optical Character Recognition Systems" for reading typed or printed text, as input data, into a computer.

Another kind of "seeing" machine which a number of groups around the world are trying to design is a robot rover, which will roam on the surface of Mars under the control of a computer which will look at the terrain around it through a television camera. While such a machine may not have the practical utility of optical character recognisers, the general principles underlying its construction are bound to be useful in a variety of ways. These robot rovers will probably be of great public interest in the next few years. The Russian Lunokhod on the Moon is already being controlled from the Earth. The radio-controlled rover carries a television camera which sends a continuous picture of the terrain ahead to its controllers. Radio-control enables the controller to speed-up, slow-down, steer or halt the rover which is 3,84,400 kilometres away. However, this is a clumsy and rather slow method of control. Signals take one and a half seconds to travel the Earth-Moon distance. A vehicle moving as fast as a few metres per second could fall off a cliff or run into an obstacle by the time the television picture reached Earth and the control signals went back. In the case of a rover on Mars, the situation would be much worse, as signals would take ten to fifteen minutes to travel one way. This makes computer control of the vehicle very useful, if not essential.

The problem of pattern recognition

High school science tells us that the eye resembles a camera in certain ways. A lens creates an image of objects in front of it. This image falls on the retina which has a large number of light-sensitive nerve cells. Cells at different positions on the retina send electrical impulses to the brain at different rates, depending upon the amount of light falling on them. But we don't normally realise that these facts alone do not explain sight. If we had nothing more than a lens and a number of light-sensitive cells, we would only know the difference between brightness and gloom. But there is more. There is a part of the brain, the visual cortex, which performs an elaborate analysis of the electrical impulses coming from the eye.

Why do we need this elaborate processing? Is it not true that an image of a given object will always cause more light to fall on some positions of the retina and less on others? No. Though the shape of an object may stay the same, its image on the retina is changing all the time. Bringing the object closer, moving it farther, moving it to the left or right, rotating it, increasing or decreasing the illumination in the room — all these operations change the image. In most cases, the original image undergoes geometrically describable changes, called transformations,

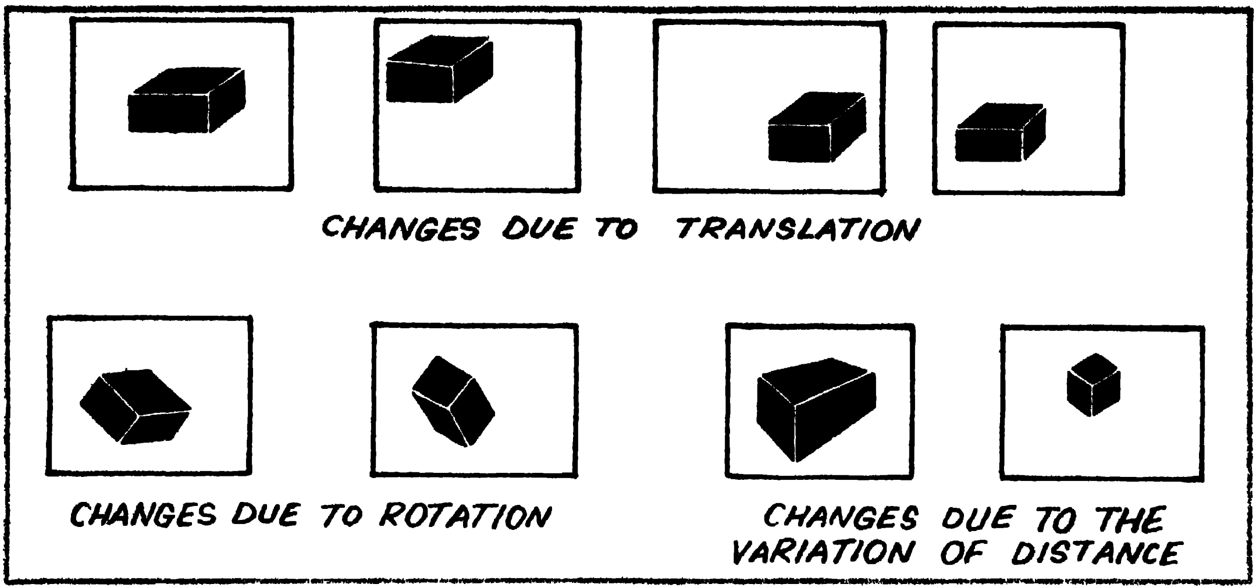

CHANGES DUE TO TRANSLATION
CHANGES DUE TO ROTATION
CHANGES DUE TO THE VARIATION OF DISTANCE

Fig. 1 The different retinal images of a cube

to become the new image (see fig. 1). Thus recognition of the image must take into account the presence of any such transformation. Sometimes transformations do not prevent us from recognising the image instantly. From whatever angle we see a cube, it is recognised as a cube. At other times, a transformation changes an image so much that it becomes identical to the image of another object. For instance a rotational transformation converts ' 6 ' into ' 9 '.

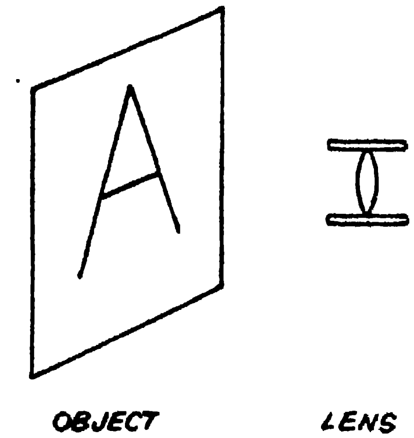
Fig. 2 shows a scheme for converting an optical image into an array of electrical signals. Depending upon the number of photocells used, the array of signals is a more or less accurate reproduction of the image. Since each photocell creates a signal representing the light falling on a small area in the image plane, we can recreate the optical image from the electrical signals. Such a recreated image will show how accurately the process converts optical information into electrical signals. Fig. 3 shows a few letters reconstructed from their electrical representation in this manner. It is now easy to see how the same letter gives rise to various different arrays of electrical signals. A line could be a little longer in one image than in another, a little more inclined or less inclined, thicker or thinner; or, there could be an unimportant discontinuity in a line. There are simpler ways of converting an optical image to an electrical form — we could use a television camera. However, we will continue to refer to the photocell array for the sake of simplicity.

Obviously, recognition of an object described by an array of electrical signals requires considerable analysis. Two arrays which are different may arise from the same object. Any given object may create a large number of arrays, all different from one another. How do we ignore the minor variations and look for a pattern in the array of signals? If we can specify in detail how this is to be done, it wouldn't be difficult to build a machine. Such a machine when connected to an array of photocells would recognise objects.

Vision in animals

Psychologists have always been aware of the elaborate processing that sensory data have to undergo. The sense organs such as eyes provide this data in the form of neuro-electrical impulses. Such data are voluminous and are constantly undergoing change. The essential features of the data are abstracted and organised by the brain to give rise to the meaningful appearance of a reasonably stable visual world that is so familiar to us. As you stand at a street corner and watch a bus moving along, the

Fig. 2 Sensing an optical imaga



millions of nerve impulses that run into your brain every second constitute a flood of data that remain incoherent until they are organised properly. From this flood of data the miraculous *perceptual* processing creates the appearance of a permanent object — a bus — running smoothly along.

Sensation requires only the existence of nerve cells sensitive to external stimuli — light, sound, heat and so on. Perception requires organisation of sensory information.

In the beginning of this century, there were considerable doubts regarding the perceptual capabilities of animals. Could one set up laboratory experiments to show that animals are capable of discriminating one visual pattern from another? For instance, could one train a rat to differentiate between a circle and a square?

The initial experiments in this direction were failures and it was even suggested that rats were not capable of this kind of visual discrimination. Then in 1930, Lashley created an improved apparatus (Fig. 4) by which it was possible to demonstrate visual discrimination in the rat. In Lashley's jumping stand, there are two different visual forms to be discriminated between. They appear on two different cards, mounted on swing doors. One of the doors is left free to swing and a jump to this door is rewarded by access to food. The other door is locked and a jump to that is naturally punished with a fall.

We need not consider the reasons that make it possible to demonstrate visual discrimination using Lashley's setup, which was so difficult with the earlier ones. The interesting fact is that having a clearcut method for testing animals for form perception, Lashley and a number of people after him proceeded to investigate areas of the brain which were involved in the perceptual processing of sensory data. Before we look at these fascinating investigations, it will be useful to look at a simple machine which is a crude model accounting for a few features of form perception and learning in animals. The machine is called a " perceptron".

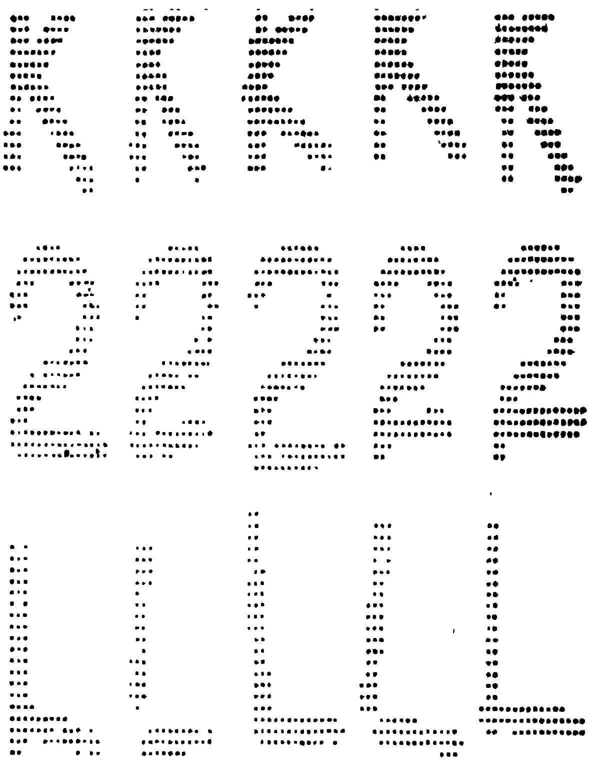
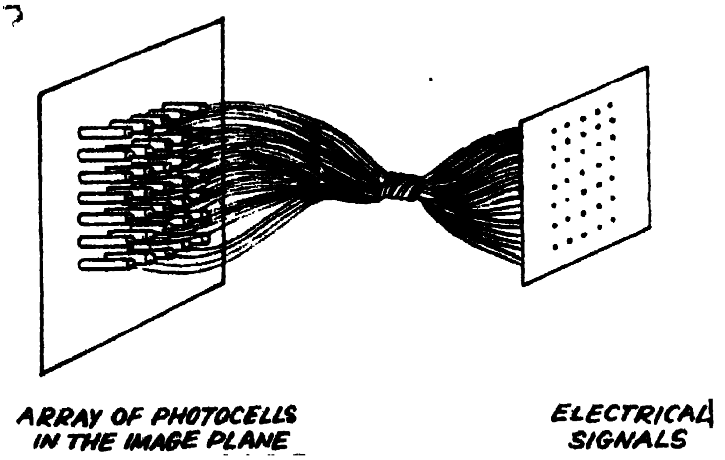


Fig. 3



The perceptron

In the late fifties, this device, invented by the psychologist Rosenblatt, attracted considerable attention. While it is no longer considered to be a model useful in investigating perception in living creatures, it is still worth looking at — simple and interesting in its own right. It is easy to describe the perceptron, if one uses the terminology of animal experiments.

Consider the perceptron as a visual learning machine. The perceptron can be tested for its performance, just as a rat can be tested on the Lashley stand. Suppose you want the perceptron to recognise the numeral ' 2 ' (Fig. 5B) and expect it to indicate recognition by flashing the light marked JUMP. When it is shown a sketch not containing ' 2 ', the perceptron is expected to flash the light marked DON'T JUMP. *Training* information can be given to the perceptron by pressing the button marked REWARD whenever it flashes the expected light and pressing the button marked PUNISH whenever it fails to perform as expected. After a number of trials the machine would be expected to perform faultlessly.

The processing of information that goes on in the perceptron can be divided into two parts. Assuming

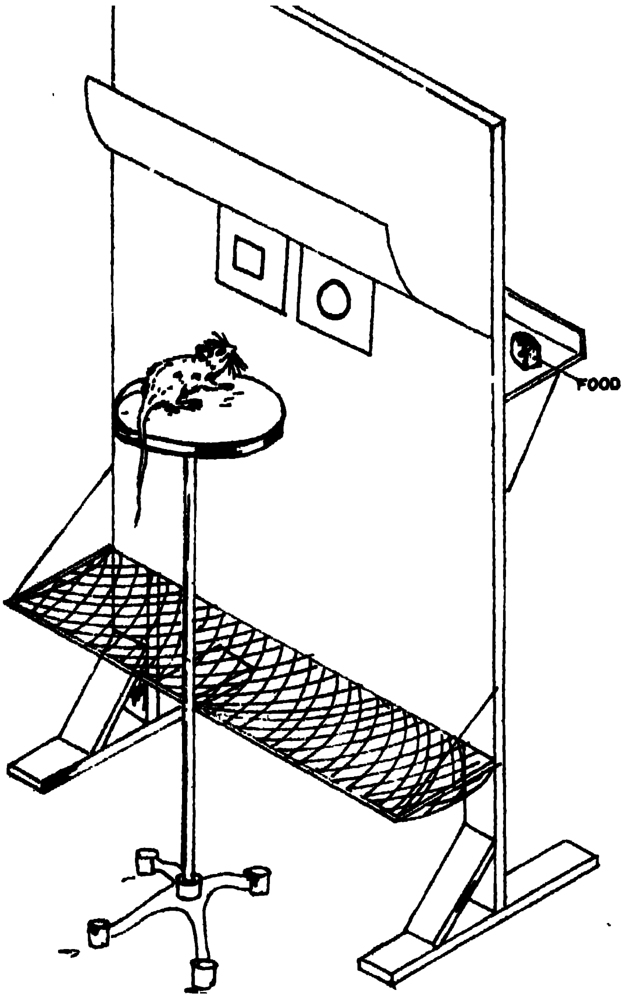
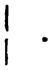
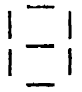
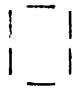
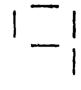
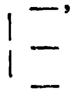


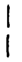
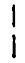
Fig. 4 Set-up for testing visual discrimination in animals

that the perceptron starts with an array of electrical signals as input (Fig. 2), the first part of processing detects the presence of *local features* such as *lines*, *curved segments* and so on. By choosing different types and numbers of local feature detectors, one can get perceptrons with different capabilities (see inset, p. 16).

The second part of the perceptron receives signals from the first part — signals carrying information about local features detected. One has to use all this information as evidence in making any decision about the nature of the given object. The perceptron employs the principle of *weighted addition* in summing up the evidence. If a detector reports the presence of a local feature, we can give its signal the value ‘ 1 ’, otherwise the value ‘ 0 ’. By multiplying the value of each signal by a suitable *weight* (a given number, positive or negative) and summing up, one obtains a numeric descriptor, S, of the given object. If S is positive, it would indicate that the given object is of the type recognised by the perceptron. If S is negative, the object does not belong to the recognised class. In the terminology of animal tests, the perceptron flashes the JUMP light if S is positive; if S is negative, the DON'T JUMP light comes on.

Learning in perceptrons

To recognise any visual form, the perceptron requires a set of weights. If the perceptron is to imitate an animal that is capable of visual learning, then it should be able to find its own set of weights. This it has to do using the REWARD and PUNISH informations. Fig. 7 shows a technique which enables the perceptron to do exactly this. Consider the perceptron in Fig. 6 being trained to recognise the form  . It has local feature detectors for seven line segments. After being punished for jumping at ‘’, ‘’, ‘’, etc, it will assign large negative weights to the five segments in ‘’.

After being rewarded for several jumps at ‘’, it will have positive weights for the two segments in ‘’. Any later trial will show the perceptron behaving as expected.

Limitations of the perceptron

Using the perceptron principles, one can programme a general-purpose computer to recognise visual patterns. In this manner, it is possible to carry out elaborate experiments. Another way of studying the perceptrons is to investigate them mathematically. Given the specifications of the local feature detectors, can we prove anything about the perceptron? Can it recognise all connected figures? Can it recognise the class of convex figures? We can ask many such questions and attempt to answer them mathematically.

The general concensus is that the perceptron is not a very successful machine. In practice, it is very difficult to design a perceptron to recognise complex visual objects. The principle of weighted addition seems to be too simple to be a useful organising principle. Because of this simplicity at the summing level, the local feature extractors have to be made very elaborate and numerous. And, in addition, in many cases the learning technique used in the perceptron turns out to be too time-consuming. The perceptron has to be shown so many pictures during *training* that, in practice, it is not possible to carry out this training. We may note here that using a matrix of 100 photocells, (10 rows and 10 columns) one can create 2^{100} pictures. At the rate of 100 pictures per second, one will need billions and billions of years for showing them all to the perceptron.

More successful machines

In an effort to overcome the limitations of the perceptron, several other machines have been thought of, and tested.

One of them starts with information about the positions of local features on a given picture. Then it solves a set of mathematical equations to find out the object in the picture. These equations basically capture the details of geometric transformations which relate different pictures of the same object. As shown in Fig. 1, these transformation provide for movement and rotation. Such a machine can easily recognise pictures of simple objects such as cubes, cylinders and pyramids seen at any reasonable distance and in any orientation.

Images of complex objects require a more general theory. This theory has to recognise that, in general, complex objects are made up of simpler objects put together. The simpler object, in turn, may be made up of still simpler ones. It is, therefore, convenient to describe the form of an object using a set of rules. Starting with local features such as line segments, curved segments, junctions, corners, ends of lines, etc, these rules describe the assembling of the form. Lower level rules describe how the local features are put together to form simple objects. Higher level rules describe how the simple objects are put together to describe more and more complex objects. For instance, you might describe the hands of a clock by saying that they are long line-like objects with a sharp end. Then you might describe the numerals by saying how they can be put together using local features. Finally, you can describe the clock in terms of an arrangement of numerals and hands.

Optical character recognition

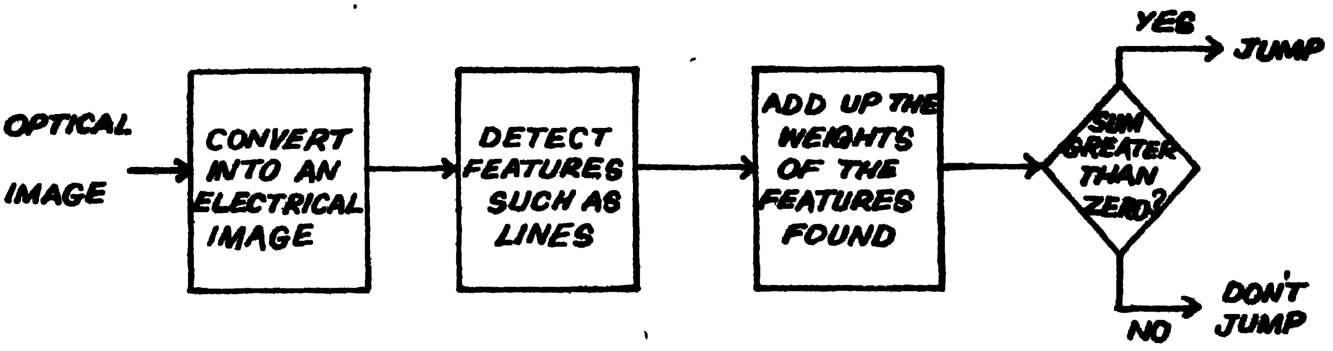
When a bank or a business organisation bu a Rs. 15 lakh computer, it often buys Rs. 20 lakh worth of card punching machines. A hundred or two hundred operators are then hired to operate these machines. The machines are similar to type-writers. But instead imprinting the information on a sheet of paper, they punch holes into a punch-card which resembles a post-card in size and thickness. When these cards are read by a reading unit in the computer, photocells detect light passing through these holes. Different patterns of holes stand for different symbols.

While a big computer can add a million numbers every second, an operator can punch only ten numbers in the same time. Information in any form — hand-written, typed or printed — has to be read by an operator and laboriously hand-punched.

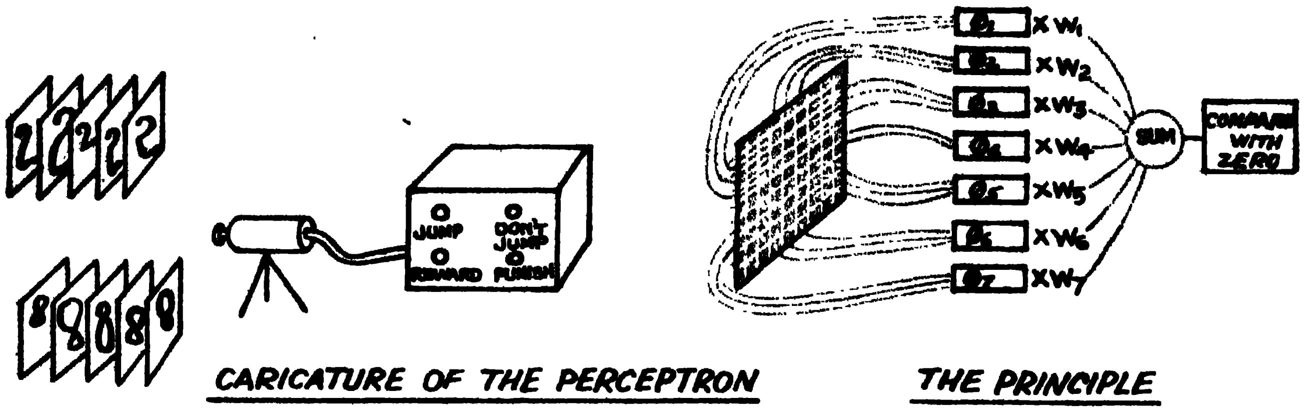
Fifteen years ago, engineers seriously started designing machines which will avoid this bottleneck. After a great deal of research and development, many companies succeeded in this task. Now there are in the market optical character recognisers through which a computer can directly be fed several thousand pages of information every hour. Usually such a recogniser reads typed or printed sheets. But there are also a few advanced machines that read hand-written material.

This approach to the description of pictures, called the syntactic approach, reminds one of the grammatical rules of a language. The grammatical rules describe how words can be strung together to make phrases, how phrases may be strung together to make more complex phrases, and then how these can, in turn, make sentences. Similarly, given a

Fig. 5 A


OPTICAL IMAGE
CONVERT INTO AN ELECTRICAL IMAGE
DETECT FEATURES SUCH AS LINES
ADD UP THE WEIGHTS OF THE FEATURES FOUND
SUM GREATER THAN ZERO?
YES
JUMP
NO
DON'T JUMP

THE PERCEPTRON'S METHOD FOR GROUPING PICTURES INTO TWO CLASSES



CARICATURE OF THE PERCEPTRON

THE PRINCIPLE

Fig. 5B

string of words, one can use these rules to analyse that string and see if they make a proper sentence. In the same way, given the rules of a " picture grammer ", a computer can analyse the picture, identify its various components and then recognise the type of picture it is. There are computers which have been designed or programmed to work on these principles.

How does the brain process visual information?

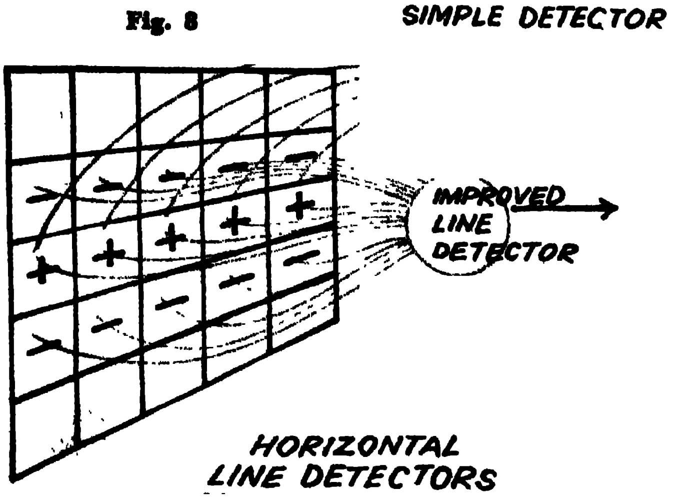
As we saw earlier, there are many principles of information processing that one can use in constructing a " seeing machine ". Obviously, there is no exhaustive list of such principles. New ones may yet be found. In this connection, it is interesting to look at what the neurophysiologist has to say. In fact, a full understanding of the complex phenomena of vision may not be possible unless there is a commerce in ideas among workers in different fields related to these phenomena.

It was found, ten or fifteen years ago, that the retina of the eye is not a simple array of light-sensitive cells. It is true that there are around a hundred million light-sensitive cells in each retina. But all these cells do not directly send their outputs to the brain. Some analysis takes place in the retina itself. Instead of sending all the raw data to the brain, the retina sends only the results of the analysis. After the local analysis in the retina, around a million nerve fibres are sufficient to carry the information to the brain.

Local feature detectors

The local feature detectors, marked ϕ_1, ϕ_2, ϕ_3 .... ϕ_7 in Fig. 5B, are small electrical circuits that perform simple tasks. For example, to detect a straight line segment of light falling on an array of photocells, one could use what is called an *and circuit* (also called a *coincidence circuit*). Fig. 8 shows an array of photocells on which we can project an optical image. We could take five signals coming from the five cells marked with a ' + ', and connect them to *and circuit*. This circuit gives an output only when all the five inputs report the presence of light on the respective photocells. The *and circuit* gives no output if one or more photocells connected to it have no light falling on them.

Fig. 8



HORIZONTAL LINE DETECTORS

The *and circuit* could, however, be wrong because it reports a line even when light is flooding the whole array. An improved straight line detector could be made by connecting all the ' + ' cells aswell as the ' — ' cells to an improved circuit. This circuit reports a line only when light is falling on all the five ' + ' cells and no light is falling on any of the ' — ' cells.

It is easy to design detectors for many other local features, such as junctions or crossovers of lines, corners made by two lines, etc. For instance, connecting two line detector outputs to an *and circuit* gives us a junction detector.

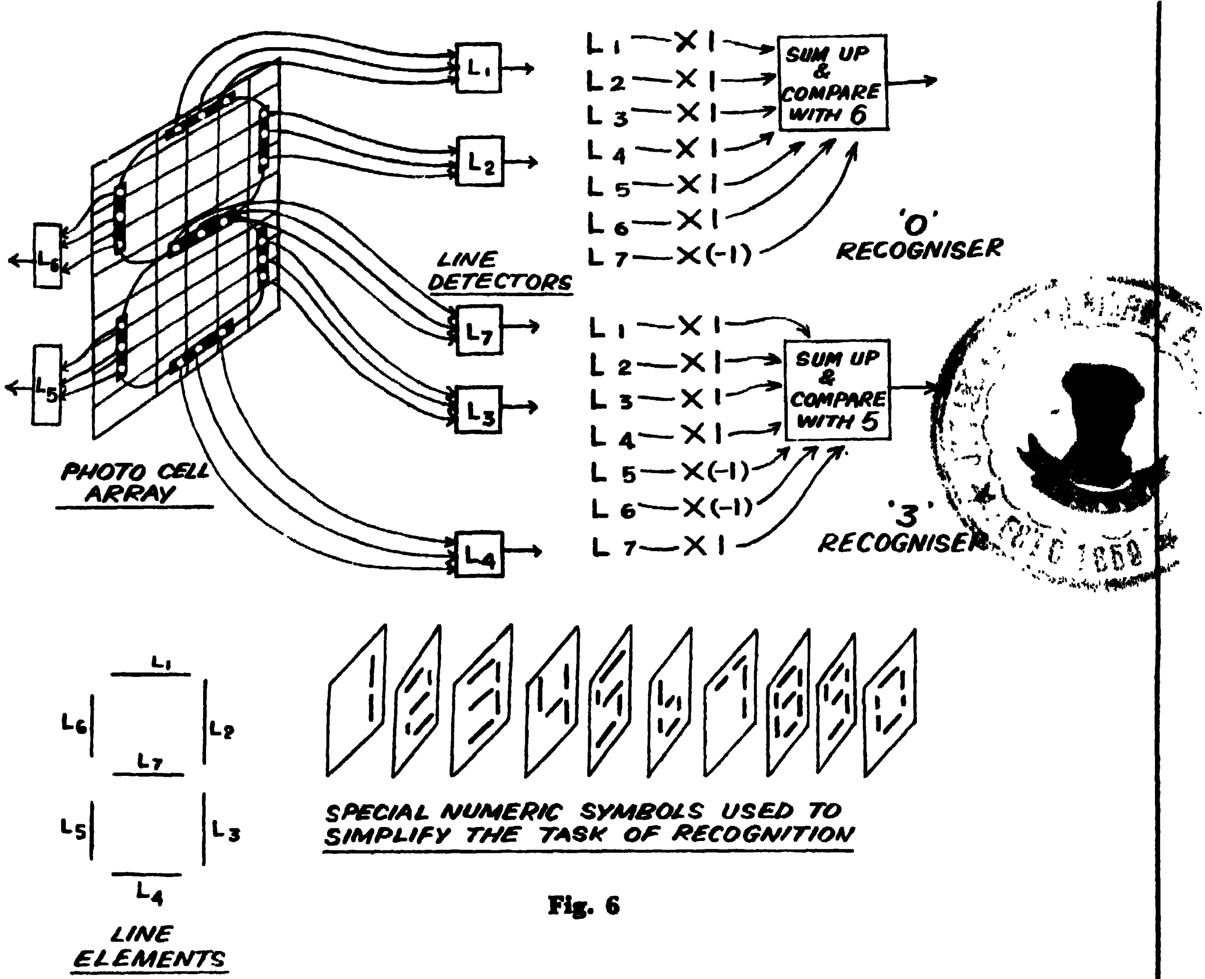
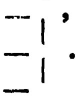


Fig. 6

Fig. 6 shows a very simple perceptron which recognises the numeral '3' written in the specific form . The image of the numeral falls on 35 photocells arranged in an array of seven rows and five columns. There are seven local feature detectors which detect seven basic line segments. By summing up the seven feature detector outputs (L_1, L_2, L_3, ... , L_7) with appropriate weights, we obtain the perceptron recognising . By using the same seven feature detectors and summing up their outputs with different sets of weights, we get perceptrons for recognising the other nine numerals. For the sake of simplicity, these perceptrons are based on a comparison of the weighted sum with a given number rather than a comparison with zero. By a simple modification, one can restrict oneself to a comparison with zero at the end.

The extreme simplicity of the perceptrons in Fig. 6 limits their capabilities severely. Any transformation of the input image will prevent its recognition. Obviously, using the same basic principles, it would be possible to construct more sophisticated perceptrons.

The neural pathway from the retina to the visual cortex of the brain maintains some systematic order. That is, the cells in a given area of the cortex will all receive their input from a circumscribed area of the retina. Further, as one follows cortical connections along the neural pathway, the interconnections between parallel paths are found to be relatively short. So, it appears natural that the cortical cells should detect local features of the visual input using the electrical messages that travel up the pathway. We will shortly see how this expectation can be verified.

It is possible to observe cortical neurons in action, using microelectrodes. Many interesting discoveries have been made during the last decade, principally by the Harvard neurophysiologists Hubel and Wiesel.

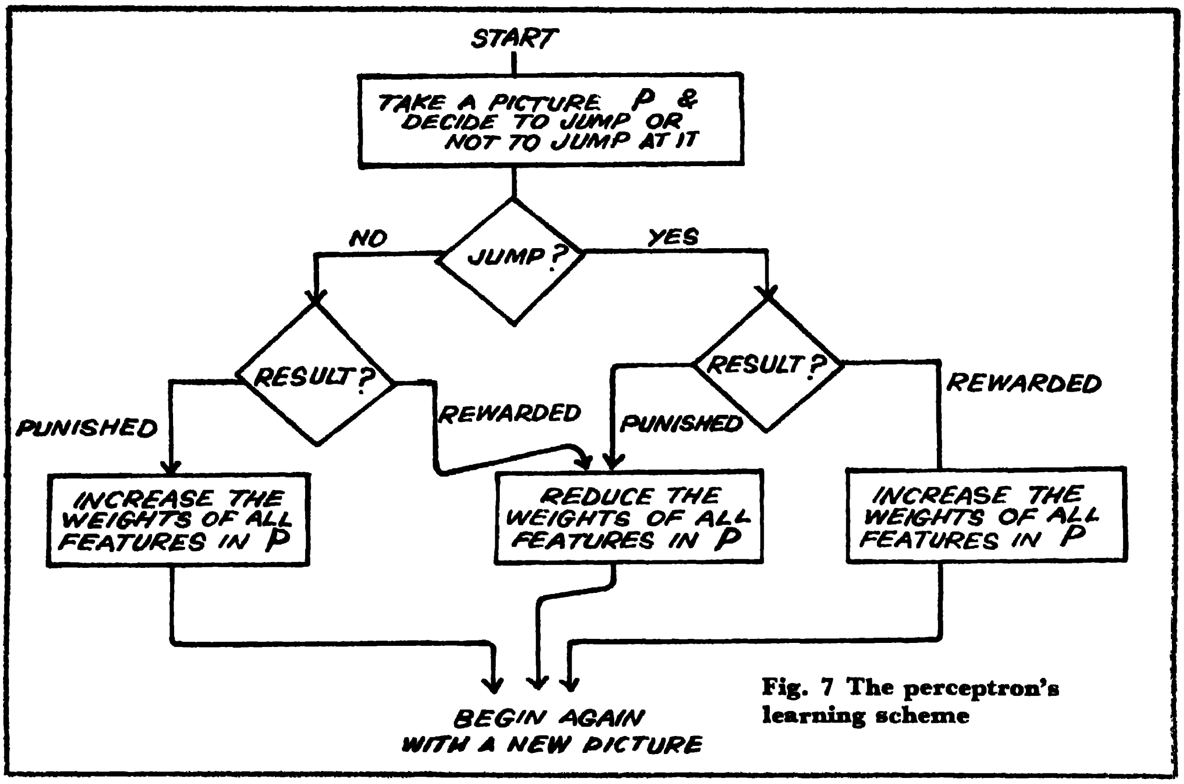

START
TAKE A PICTURE P & DECIDE TO JUMP OR NOT TO JUMP AT IT
NO
JUMP?
YES
RESULT?
PUNISHED
REWARDED
RESULT?
PUNISHED
REWARDED
INCREASE THE WEIGHTS OF ALL FEATURES IN P
REDUCE THE WEIGHTS OF ALL FEATURES IN P
INCREASE THE WEIGHTS OF ALL FEATURES IN P
BEGIN AGAIN WITH A NEW PICTURE

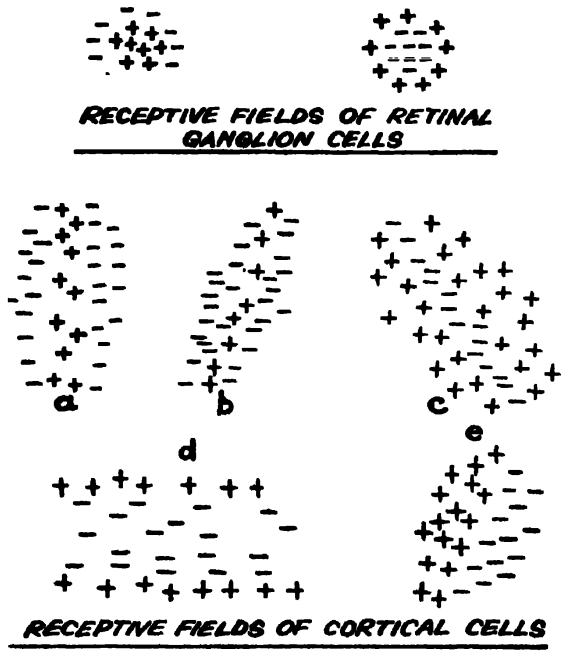
Fig. 7 The perceptron's learning scheme

In a typical experiment, they placed an anaesthetised cat in front of a screen on which various patterns of light could be projected. Simultaneously, they observed the activities of single cortical neurons using a microelectrode. This was a very thin tungsten wire insulated all the way, except at the tip. From the anatomical clues mentioned above, one would expect only some small region of the retina to be sending signals to any cortical cell. Where is this region on the retina, corresponding to a given cortical cell?

Finding this is easy in principle, though laborious in practice. Note that the animal is anaesthetised and does not move its head or its eyes. Consider any pattern projected in a given small region on the projection screen. Obviously, the image of this pattern will fall at some specific place on the retina. So, one can project various patterns of light at various places on the screen and observe the signals picked up by the microelectrode. This will show the effect of light at different retinal positions on the electrical activity of a given cortical neuron. In practice, however, it might take hours to find the appropriate position and the appropriate pattern to which such a neuron is sensitive.

It is also possible to use a small spot of light instead of an elaborate pattern to make such an exploration. Suppose you position the projector to place a spot of light at a suitable place on the screen. You can then switch the projector on and off and see if the electrical activity of the neuron is altered by this. Depending upon the position, the light may excite the neuron into rapid firing, or alternately, inhibit it. Obviously, signals from the light sensitive cells on some region of the retina determine the outputs of this neuron. Different neural connections could determine which signals will be excitatory and which

Fig. 10 Local feature extractors in the visual cortex


RECEPTIVE FIELDS OF RETINAL GANGLION CELLS
a
b
c
d
e
RECEPTIVE FIELDS OF CORTICAL CELLS

will be inhibitory. By repeated observation we can make a map to show the spatial arrangement of excitatory and inhibitory areas.

As the light spot is projected at different positions on the screen, one can mark them, a ' + ' for the positions where light stimulus causes excitation of the cortical neuron and a ' — ' for the positions where light causes inhibition. Fig. 10 shows several such maps showing the receptive fields of different cortical neurons, as reported by Hubel and Wiesel.

The difference between maps showing the receptive fields of retinal ganglion cells and those of the cortical cells are very striking. Some cortical cells seem to have receptive fields (Fig 10, a and b) with excitatory areas running in a straight line, surrounded on either side by inhibitory areas. There seem to be cells with receptive fields with all possible orientations of the line-shaped excitatory areas. Similarly, there are cells with a line-shaped inhibitory areas (Fig. 10, c) in the middle and excitatory areas on either side.

Cortical cells and local feature detection

After the receptive field of a cell has been mapped out, it is easy to predict the visual pattern which will cause maximum activity in that cell. For instance, consider a pattern which will cause maximum activity in the cell having a receptive field as shown

Information processing by nerve cells

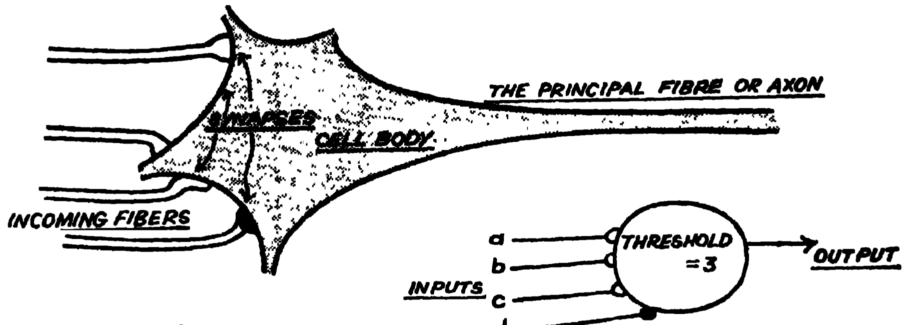


Fig. 9

A NEURON

THE SIMPLIFIED MODEL

Even to get a glimpse of what goes on in the brain, one needs to know something about nerve cells, or neurons. A grossly simplified picture of nerve cells and their interconnections is given in Fig. 9. The few components of the neuron shown in this figure include *synapses*, which are junctions made by incoming nerve fibres with the neuron, the *cell body*, and the principal fibre or the *axon*. Nerve cells transmit electrochemical disturbances along their outer membranes, particularly along the axon. When an electrochemical disturbance is passing along its membranes, a neuron is said to be *firing*.

When a disturbance travelling along an incoming fibre reaches the synapse, it can cause there the release of a specific substance. This substance travels outward to the cell body and, in some cases, excites the associated neuron into firing. Depending upon the nature of the synapse, the specific substance may alternately inhibit firing of the associated neuron.

Each cell could have several thousand incoming fibres synapsing with it while, in turn, it sends fibres to many other cells. The firing of such a cell would be controlled collectively by the inputs that reach it through the synapses. A useful simplification is that the excitatory inputs add up to increase the tendency to fire. The inhibitory inputs add up to result in a countereffect which tends to suppress firing. We can visualise the inputs being all summed up, excitatory ones having a positive value and the inhibitory ones having a negative value. If the resulting sum exceeds a given value, the threshold of the neuron, it is triggered into firing. The number of times a neuron fires in a second is to some extent proportional to the excess of total input above the threshold.

This simplified picture of the neuron reminds us of the summing device in the perceptron. The similarity is enhanced by the fact that different synapses could have different amounts of excitatory or inhibitory influence over the same neuron. "Weighted" addition is therefore possible in a neuron.

Another interesting fact can be brought out using this simple picture. A neuron can act as an *and circuit*. The simplified model in Fig. 9 is that of a neuron with three excitatory inputs (a, b and c) and an inhibitory one (d). The threshold for firing is such that all the three excitatory inputs should be active for firing to occur. In addition, the inhibitory one should not be active. We can write this condition for firing by saying that *a and b and c* should be active *and d* should not be active.

Other arrangements of synaptic inputs and thresholds can enable a neuron to detect various other combinations of input. This could be the basis for local feature detectors.

in Fig. 10, a. Obviously, this pattern should illuminate all the areas marked with a ' + ' and not illuminate any area marked with a ' — '. This pattern turns out to be a thin vertical rectangle or a line. We can test this suggestion by projecting a vertical bar of light at the right position on the screen (Fig. 11). As the projector is switched on, the cell responds with rapid firing. Then we can rotate the projected bar of light, as shown in Fig. 11. This reduces the strength of the response considerably. When the rotation is more than 10° or so, the light stimulus ceases to create any significant response. Similarly, changing the position of the vertical bar of light on the screen abolishes the response.

This, then, is the evidence for the existence of local feature detectors in the visual cortex. The cell discussed above is a vertical line detector. The cell mapped in Fig. 10, b is a line detector sensitive to lines with another orientation. Fig 10, c shows a dark line detector. Feature detectors known to exist are not limited to line detectors. The receptive field in Fig. 10, d is obviously that of a cell which detects dark horizontal bars — bars having a substantial width. The receptive field in Fig. 10, e is that of an " edge detector ". It seems that there are also cells which are " moving line detectors ". These cells have receptive fields (to some extent resembling the one in Fig. 10, e) which are specially suited to the detection of moving lines. One can project a line along an edge of the receptive field and start moving it. At a given place, the moving line suddenly moves from the inhibitory area to the excitatory area. The resulting change in the signal reaching the cortical cell seems to cause rapid firing.

Hubel and Wiesel explored various areas in the cat's visual cortex by observing cortical cells in those

Information processing in the retina

The signals from light sensitive cells of the retina reach what are called retinal ganglion cells. The connections are so arranged that signals from many light sensitive cells affect the activity of a retinal ganglion cell. In this manner, the ganglion cells are able to combine, in a meaningful way, the signals coming from a small region of the retina.

It is possible to place a microelectrode close to a retinal ganglion cell and observe its electrical activity. As one would expect, it is found that the activity of such a cell is affected only by a part of the retina, called the receptive field of this cell. If a light stimulus is applied to the receptive field, or withdrawn from it, the cell changes the rate at which it sends electrical inpulses to the brain.

Some cells increase this rate, called the firing rate, when light falls in a central area of their receptive fields. These cells will decrease their rate of firing if light falls in the peripheral areas of the receptive fields. Other cells have the opposite arrangement, with an inhibitory area in the center of the receptive field and an excitatory area in the periphery.

When there is uniform lighting over the retina, the excitatory effect of a part of the receptive field is cancelled by the inhibitory effects of the rest of the receptive field. Under these conditions, the ganglion cell does not seem to send a signal. A patterned image with contrasts, boundaries, lines, isolated spots, etc activates a large number of ganglion cells. This then, is the kind of processing that visual information undergoes in the retina.

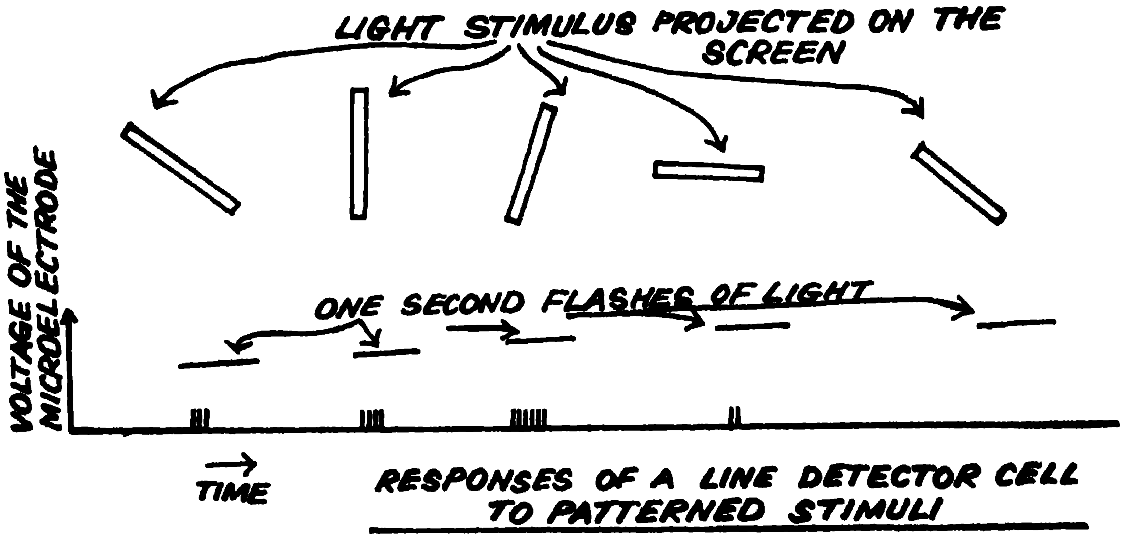

LIGHT STIMULUS PROJECTED ON THE SCREEN
VOLTAGE OF THE MICROELECTRODE
ONE SECOND FLASHES OF LIGHT
TIME
RESPONSES OF A LINE DETECTOR CELL TO PATTERNED STIMULI

Fig. 11

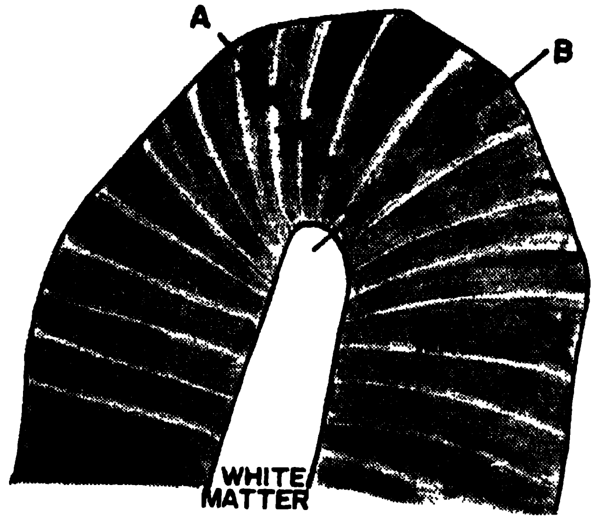


Fig. 12 Columnar arrangement of cells in the visual cortex

areas with microelectrodes. Fig. 12 illustrates the finding they made in this manner. The cells seem to be arranged in columns running from the surface to the white matter deeper down in the brain. There seems to be some similarity in the function of the feature detector cells in any given column. There may be line detectors, dark line detectors, edge detectors and so on, within a column. But they all seem to be detecting features with the same orientation. This is very neatly demonstrated by moving the microelectrode as shown by the line A. Such an oblique penetration of the cortex presents cells sensitive to features with different orientations. As the microelectrode goes deeper and deeper, there is a gradual rotation of the orientation to which the observed cells are sensitive.

Work in this particular field has gained momentum in the last ten years. Following the original discoveries of what they called " simple cortical cells " (described above), Hubel and Wiesel have discovered even more interesting cells in the cat's visual cortex. They found " complex cortical cells " which detect features in a given area. A simple line detector responds to a line only in a given position. On the other hand, the complex cell functioning as a line detector will respond to a line of the correct orientation whenever it is within a given area.

Another interesting discovery is that of cortical cells which are sensitive to information coming from both eyes. Evidence is accumulating in favour of the theory that these cells compute depth information. Since the two retinal images are displaced with respect to each other as a function of the object, such binocular mechanisms could be distance-sensitive.

More recent work has uncovered what are called " hypercomplex cells. " These cells respond to a line of suitable orientation, anywhere within a given receptive field. In this, they are similar to the complex cells. But, the hypercomplex cells do not at all respond if the line is very long. On the other hand, if the line comes to an end within the receptive field, these cells create a response. The response is still better if the line turns within the receptive field to go off at an angle to its original direction. We can hypothesise that hypercomplex cells participate in the detection of corners and sharp curvatures.

What more does the brain do?

Obviously, there is a lot more to be found out before our understanding of visual perception becomes satisfactory. No doubt, the discovery of feature detectors is a very encouraging step. The fact is that we now roughly understand how the basic computations necessary for such feature detection takes place in small systems of neurons. We can show how appropriate interconnections between a number of neurons could result in a system suitable for such feature detection. However, there is still a wide gap in our understanding of the brain's activity. For instance, what happens to the output of feature detector neurons? Information on the presence of features alone cannot create perception. Two pictures could be composed of the same set of features and still be different, as is crudely illustrated by Fig. 13. How, then, does the brain put together this information on the presence of lines, bars, edges, ends and corners? The perception model is not good enough.

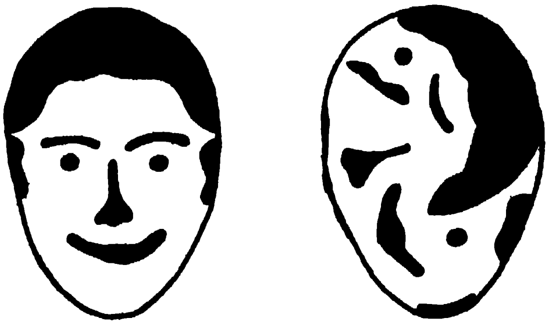


Fig. 13 Pictures and picture elements (features). Recognition of a picture requires a knowledge of the features present in it as well as their positions relative to each other

As we saw earlier, the computer scientists have a similar problem on their hands. How can a machine put together the information from feature detectors to describe a picture? What is the nature of good descriptions of pictures in terms of features? Perhaps, this decade will throw some light on both these problems. We might also hope that any step towards a better understanding of one problem will help in understanding the other.

In 1894 or 1895, the young Albert Einstein wrote an essay on the "State of Aether in Magnetic Fields". He sent the essay, most probably his "first" scientific work, with a letter to his uncle Cäsar Koch. Both the letter and the essay are presented here with some comments on the origins of Einstein's ideas on Special Relativity

Albert Einstein's "First" Paper

JAGDISH MEHRA

"Concerning the Investigation of the State of Aether in Magnetic Fields"

ALBERT Einstein always maintained that the trend of thinking that ultimately led to his work *Zur Elektrodynamik bewegter Körper* (On the Electrodynamics of Moving Bodies) had already begun when he was an adolescent young man. In conversations and interviews at various times, several people sought to find out from Einstein himself about his intellectual and scientific development in order to fix the chronology of the conception, gestation and birth of the Special Theory of Relativity. We know very little about Einstein as a boy and young scholar other than what he has himself mentioned in scattered writings or told his biographers and interviewers.

Gerald Holton, in his article "Influences on Einstein's Early Work in Relativity Theory", reported on his search in documents, diaries, notebooks, correspondence, and unpublished manuscripts in the Einstein archives at Princeton and other source materials for any indications relating to Einstein's 1905 paper on relativity, concluding that "there is no contemporaneous draft or manuscript from which one might learn something of the genesis of the paper."

The forgotten teacher!

Holton surveyed various books and authors that probably might have influenced the young Einstein ever since he came to the Aargau Cantonal School in Aarau in 1895, and looked for some remarks or evidence that might have started Einstein's thinking on relativity. [Albert Einstein was a pupil in the third and fourth classes of the Aargau Cantonal School in Aarau from October 1895 to early fall of 1896. In October 1896 Einstein enrolled at the E.T.H., Zurich, to study for a " Fachlehrer " (specialist teacher) diploma in mathematical physics, and was graduated in August 1900.] In these and the two notebooks of lecture notes which Einstein kept at Zurich during the period 1897 to 1900, Holton drew a blank. After a thorough and intensive search, Holton decided that August Föppl's successful book *Einführung in die Maxwellsche Theorie der Elektrizität* (Introduction to Maxwell's Theory of Electricity), first published in 1894, had a decisive influence on Einstein, that Föppl was the " almost forgotten teacher ". Föppl, as Holton noted, was called in 1894 to the Technische Hochschule at Munich where the young Einstein was then living. The suggestion is enticing that Einstein became familiar with Föppl's book shortly after it was published, learned from it the fundamentals of the electromagnetic theory of Maxwell and Hertz, was influenced by it in his formative years, and was probably inspired by it to work on the theory of relativity. The headings like " The Electrodynamics of Moving Conductors ", " Electromagnetic Force Induced by Movement ", and " Relative and Absolute Motion in Space " which occur in Föppl's book are indeed suggestive of an influence on Einstein. We should, however, remember that these topics were frequent enough in the scientific literature of the 1890s and the early 1900s, as the electrodynamics of moving bodies was one of the central problems of physics. Notation is often indicative of influence, and Einstein used Hertz' notation in his 1905 paper on relativity, not the Heaviside notation used by Föppl, indicating that Hertz' direct influence on Einstein might have been greater than it is generally assumed.

[Einstein's essay, presented in this article, clearly indicates that his interest in electromagnetism was aroused by the " marvellous " experiments of Heinrich Hertz. These experiments, since Faraday's early work, were the most important in the field of electromagnetism and were justly so celebrated at the time. Faraday had discovered the law of electromagnetic induction in 1834, and it was this law that guided Einstein in his work on Special Relativity. Einstein built his theory on experimental facts. He starts his 1905 paper by pointing out that the law of induction contains an asymmetry which is artificial, and does not correspond to facts. Empirical observation shows that the current induced depends only on the relative motion of the conducting wire and the magnet, while the usual theory explains the effect in quite different terms according to whether the wire is at rest and the magnet moving or vice versa. At the time of Einstein's writing, the law of induction was about 70 years old, and " everybody had known all along that the effect depended on relative motion, but nobody had taken offence at the theory not accounting for this circumstance." (See Max Born's " Physics and Relativity ", in *Physics in My Generation*, Springer Verlag New York Inc., 1969.)]

The first paper?

I have recently found a " paper " (an essay) which the young Albert Einstein wrote in 1894 or 1895. He sent the essay entitled " Über die Untersuchung des Aetherzustandes im magnetischen Felde " (Concerning the Investigation of the State of Aether in Magnetic Fields) with a covering letter to his maternal uncle, Cäsar Koch, who was living in Antwerp, Belgium, at that time. [I presented photocopies of these documents to Miss Helen Dukas in May 1970 for the Einstein Archives in Princeton. I am grateful to Miss Dukas and the Executor of the Estate of Albert Einstein, Dr. Otto Nathan, for permission to publish these items. I am also grateful to Jean Ferrard for allowing me to examine the letters and papers relating to Einstein in the possession of his family. Monsieur Ferrard has very kindly allowed me to publish the translation of Einstein's essay and to report on my findings for scientific purposes.]

The letter to Cäsar Koch and the essay were assigned the date of " 1894 or 1895 " by Einstein himself in 1950. (I have not been able to discover the identity of the person who showed Einstein these documents in 1950. Neither the owners of the documents nor Miss Helen Dukas, Einstein's former secretary, have any recollection of who this person was, nor could they offer any reasonable guess about his identity.) It is quite evident from the letter that he wrote the essay (during the year he spent in Milan) before he went to Zurich for the entrance examination of the " Polytechnic " [E.T.H., Eidgenössiche Technische Hochschule, Zurich — the Swiss Federal Institute of Technology]. (The choice of the E.T.H. in Zurich for Einstein's higher studies was made by his father Hermann and uncle Jakob Einstein. The two brothers at one time had founded a small engineering factory for making dynamos, measuring instruments and arc lamps, and Einstein's

Letter to Cäsar Koch*

1894 or 1895. A. Einstein (Date recalled in 1950)

My dear Uncle:

I am really very happy that you are still interested in the little things I am doing and working on, even though we could not see each other for a long time and I am such a terribly lazy correspondent. I always hesitated to send you this (attached) note; because it deals with a very special topic, and besides it is still rather naive and imperfect, as is to be expected from a young fellow like myself. I shall not mind it at all if you don't read the stuff; but you must recognise it at least as a modest attempt to overcome the laziness in writing which I have inherited from both of my dear parents....

As you probably already know, I am now expected to go to the Polytechnic in Zurich. However, it presents serious difficulties because I ought to be at least two years older for that. We shall let you know in the next letter what happens in this matter.

Warmest greetings to dear aunt and your lovely children,

from your
Albert

* Einstein's maternal uncle; sometimes in letters and addresses the name has been spelt with the French accent as "César". (Author's translation of the letter.)

●●

Cäsar and Jakob Koch were the two brothers of Einstein's mother Pauline. Jakob lived in Zurich and his name occurs several times in the Einstein-Besso correspondence. Cäsar Koch seems to have been Einstein's favourite relative. In one of the letters to Cäsar, Einstein remarks: "....Bist Du mir doch immer der Liebste in der Familie gewesen." After his marriage to Mathilde Lévy at Basle in 1888, Cäsar went to Buenos Aires; following a sojourn there and return to Basle, he settled in Antwerp, Belgium, around 1891, and moved to Brussels after the first World War. He was a merchant of commodities. Cäsar Koch was very fond of Albert Einstein and encouraged him in his boyhood studies. Einstein visited the Koch family when he attended the first Solvay conference in Brussels in 1911. In the 1920s, when Einstein used to visit Ehrenfest in Leiden and gave lectures there, or en route to Paris from Berlin, he always visited his uncle Cäsar. These personal contacts were continued when Einstein attended the fifth and sixth Solvay conferences in Brussels, in 1927 and 1930 respectively, and during the months he spent as a refugee from Germany at Le Coq sur Mer near Ostende before his final departure from Europe to the United States. Later on affectionate correspondence between Einstein, his wife Elsa, his sister Maja, and the Koch family was maintained.

I am grateful to Madame Suzanne Gottschalk, daughter of Cäsar Koch, for conversations about Einstein and her family, and for showing me numerous letters and photographs. ●●

initial plan was to study engineering in Zurich.) The essay therefore predates all source materials to which references have been made in connection with the origins of the theory of relativity. Before presenting Einstein's letter and essay, let us review some of the autobiographical and interview comments which are on record; all of them dwell upon Einstein's recollection of the vague beginnings of the " relativity problem " going back to his Aarau days.

Thus the psychologist Max Wertheimer recalled " those wonderful days ", beginning in 1916, when he questioned Einstein for hours on end alone in his study and heard from him the story of the " dramatic developments which culminated in the theory of relativity." Wertheimer probed Einstein for the " concrete events in his thought ", and Einstein described to him the genesis of each equation in great and specific detail.

By the time the conversations with Max Wertheimer took place, Einstein had already completed the main edifice of his theory of gravitation and the general theory of relativity, and he could take a long look back and reminisce about a glorious intellectual adventure. As Wertheimer recalls, " The problem started when Einstein was sixteen years old, a pupil in the Gymnasium (Aarau, Kantonschule). He was not an especially good student, unless he did productive work on his own account. This he did in physics and mathematics, and consequently he knew more about those subjects than his classmates. It was then that the great problem really started to trouble him. He was intensely concerned with it for seven years; from the moment however that he came to question the customary concept of time, it took him only five weeks to write his paper on relativity . . ."

[In 1905 Einstein continued the theme of his relativity paper by discussing the dependence of the inertia of a body on its energy (*Annalen der Physik*, ser. 4, vol. 18, pp. 639–641). In 1907 Einstein wrote on the possibility of a new test of the principle of relativity (*Annalen der Physik*, ser. 4, vol. 23, pp. 197–198), the inertia of energy as a consequence of the relativity principle (*Annalen der Physik*, ser. 4, vol. 23, pp. 371–384), and " Relativitätsprinzip und die aus demselben gezogenen Folgerungen " (*Jahrbuch der Radioaktivität*, vol. 4, pp. 411–462, and vol. 5, pp. 98–99). In the last paper he explicitly stated the equivalence of inertial and gravitational mass, and gave the famous equation for mass in terms of energy. Einstein returned to the ideas of this paper in 1911 when he wrote on the influence of gravity on light (*Annalen der Physik*, ser. 4, vol. 35, pp. 898–908). The theme of relativity and gravitation was taken up in 1912, with papers on the velocity of light in a gravitational field (*Annalen der Physik*, ser. 4, vol. 38. pp. 355–369), the theory of a static gravitational field (*Annalen der Physik*, ser. 4, vol. 38, pp. 443–458), and replies to remarks of M. Abraham in short notes (*Annalen der Physik*, ser. 4, vol. 38, pp. 1059–1064; vol. 39, p. 704). A major summing up of the ideas expressed in these papers and approaches to the general theory of relativity and gravitation were made with Marcel Grossmann in " Entwurf einer Verallgemeinerten Relativitätstheorie und eine Theorie der Gravitation " (*Zeitschrift für Mathematik und Physik*, vol. 62, pp. 225–261). Einstein presented a lecture on the physical foundations of the new theory of gravitation in an address to the Naturforschende Gesellschaft, Zurich, 9 September 1913 (*Vierteljahrsschrift*, vol. 58, pp. 284–290), and continued the theme two weeks later in a lecture at the 85th Versammlung Deutscher Naturforscher in Vienna on 21 September 1913. In 1914, Einstein wrote on the formal foundations of the general relativity theory (*Sitzungsberichte der Preussischen Akademie der Wissenschaften*, part 2, pp. 1030–1085, 1914), gave several lectures on the problem of gravitation and relativity, and published a paper with M. Grossmann on the general convariance properties of the field equations of the theory of gravitation (*Zeitschrift für Mathematik und Physik*, vol. 63, pp. 215–225). Einstein continued to write on general relativity during the year 1915, and published new ideas on the application of the theory to astronomy; he also explained the perihelion motion of mercury on the basis of the general theory. Then in 1916 his great paper on the complete general theory of relativity was published: " Grundlage der allgemeinen Relativitätstheorie " (*Annalen der Physik*, ser. 4, vol. 49, pp. 769–822). In an important sense, this was the culmination of the intellectual adventure on which Einstein had started since the time he wrote to his uncle Cäsar Koch in 1894 or 1895.]

On 4 February 1950, in the first of several visits that he made to Einstein in Princeton during the period 1950–1954, R. S. Shankland asked Einstein how long he had worked on the Special Theory of Relativity before 1905. Einstein told him that he had started on the problem at the age of 16, already as a student when he could devote only part of his time to it, and worked on it for ten years. He made many fruitless attempts to develop a theory consistent with the experimental facts, but they had to be abandoned, " until it came to me that time was suspect! "

Einstein, in his conversation with Shankland, commented at length on the nature of mental processes, and emphasised that our minds do not seem to move step by step to the solution of a problem; rather, they take a devious route. " It is only at the last that order seems at all possible in a problem," said Einstein. Of a later interview on 24 October 1952, Shankland reports, " I asked Professor Einstein about the three famous 1905 papers [*Annalen der Physik*, *17*, 132, 549, 891 (1905)] and how they all appeared to come at once. He told me that the work on special relativity " had been his life for over seven years and that this was the main thing." However, he quickly added that the photoelectric effect paper was also the result of five years' pondering and attempts to explain Planck's quantum in more specific terms. He gave me the distinct impression that the work on Brownian motion was a much easier job. " A simple way to explain this came to me, and I sent it off."

Excitement about natural phenomena had come to Einstein early. At the age of 4 or 5, he had received a compass from his father to play with. The sense of wonder, of a " secret power behind the movement of the needle ", which he experienced as a child remained a deep and lasting memory with him. The various business crises of his father, which affected the fortunes of the family, did not destroy the atmosphere of free thought, experience, and sense of mystery about nature in which Einstein grew up. In 1889, at the age of ten, Albert Einstein entered the Luitpold Gymnasium in Munich. His work at the Gymnasium was a mechanical routine; but still, at the age of 12, he experienced the excitement and beauty of geometry when he came across an old textbook on Euclidean plane geometry at the school.

Of his boyhood studies, Einstein recalled in his autobiographical notes:

" At the age of 12–16, I familiarised myself

CONCERNING INVESTIGATION OF THE STATE OF AETHER IN MAGNETIC FIELDS

Albert Einstein

THE following lines are the first modest expression of some simple thoughts on this difficult subject. With much hesitation I am compressing them into an essay which looks more like a programme than a paper. Since I completely lacked the materials to penetrate the subject more deeply than was permitted by reflection alone, I ask that this circumstance should not be ascribed to me as superficiality. I hope the indulgence of the interested reader will correspond to the humble feelings with which I offer him these lines.

When the electric current comes into being, it immediately sets the surrounding aether in some kind of instantaneous motion, the nature of which has still not been exactly determined. In spite of the continuation of the cause of this motion, namely the electric current, the motion ceases, but the aether remains in a potential state and produces a magnetic field. That the magnetic field is a potential state [of the aether] is shown by the [existence of a] permanent magnet, since the principle of conservation of energy excludes the possibility of a state of motion in this case. The motion of the aether, which is caused by an electric current, will continue until the acting [electro-] motive forces are compensated by the equivalent passive forces which arise from the deformation caused by the motion of the aether itself.

The marvellous experiments of Hertz have most ingeniously illuminated the dynamic nature of these phenomena — the propagation in space, as well as the qualitative identity of these motions with light and heat. I believe that for the understanding of electromagnetic phenomena it is important also to undertake a comprehensive experimental investigation of the potential states of the aether in magnetic fields of all kinds — or, in other words, to measure the elastic deformations and the acting deforming forces.

Every elastic change of the aether at any (free) point in a given direction should be determinable from the change which the velocity of an aether wave undergoes at this point in that direction. The velocity of a wave is proportional to the square root of the elastic forces which cause [its] propagation, and inversely proportional to the mass of the aether moved by these forces. However, since the changes of density caused by the elastic deformations are generally insignificant, they may probably be neglected in this case also. It could therefore be said with good approximation: The square root of the ratio of the change of velocity of propagation (wavelength) is equal to the ratio of the change of the elastic force.

I dare not decide as to which type of aether waves, whether light or electrodynamic, and which method of measuring the wavelength is most appropriate for studying the magnetic field; in principle, after all, this makes no difference.

If a change of wavelength in the magnetic field can be detected at all in any given direction, then the question can be experimentally decided whether only the component of the elastic state in the direction of the propagation of the wave influences the velocity of propagation, or the components perpendicular to it also do; since it is known *a priori* that in a uniform magnetic field, whether it is cylindrical or pyramidical in form, the elastic states at a point perpendicular to the direction of the lines of force are completely homogeneous, but different in the direction of the lines of force. Therefore if one lets waves propagate that are polarised perpendicularly to the direction of the lines of force, then the direction of the plane of oscillation would be important for the velocity of propagation — that is if the component of the elastic force perpendicular to the propagation of a wave at all influences the velocity of propagation. However, this probably might not be the case, although the phenomenon of double diffraction seems to indicate this.

Thus after the question has been answered as to how the three components of elasticity affect the velocity of an aether wave, one can proceed to the study of the magnetic field. In order to understand properly the state of the aether in it [the magnetic

---

with the elements of mathematics together with the principles of differential and integral calculus. In doing so I had the good fortune of hitting up books which were not too particular in their logical rigour, but which made up for this by permitting the main thoughts to stand out clearly and synoptically. This occupation was, on the whole, truly fascinating; climaxes were reached whose impression could easily compete with that of elementary geometry — the basic idea of analytical geometry, the infinite series, the concepts of differential and integral. I also had the good fortune to know the essential results and methods of the entire field of the natural sciences in an excellent field], three cases ought to be distinguished:

1. The lines of force come together at the North pole in the shape of a pyramid.
2. The lines of force come together at the South pole in the shape of a pyramid.
3. The lines of force are parallel.

In these cases the velocity of propagation of a wave in the direction of the lines of force and perpendicular to them has to be examined. There is no doubt that the elastic deformations as well as the cause of their origin will be determined [by these experiments], provided sufficiently accurate instruments to measure the wavelength can be constructed.

The most interesting, but also the most difficult, task would be the direct experimental study of the magnetic field which arises around an electric current, because the investigation of the elastic state of the aether in this case would allow us to obtain a glimpse of the mysterious nature of the electric current. This analogy also permits us to draw definite conclusions concerning the state of the aether in the magnetic field which surrounds the electric current, provided of course the experiments mentioned above yield any result.

I believe that the quantitative researches on the absolute magnitudes of the density and the elastic force of the aether can only begin if qualitative results exist that are connected with established ideas. Let me add one more thing. If the wavelength does not turn out to be proportional to $\sqrt{A + k}$ [sic], then the reason (for that) has to be looked for in the change of density of the moving aether caused by the elastic deformations; here A is the elastic aether force, *a priori* a constant which we have to determine empirically, and k the (variable) strength of the magnetic field which, of course, is proportional to the elastic forces in question that are produced.

Above all it must be demonstrated that there exists a passive resistance to the electric current for the production of the magnetic field, that is proportional to the length of the path of the current and independent of the cross section and the material of the conductor. ● ●

[Einstein's essay has been translated by the author.]

popular exposition, which limited itself almost throughout to qualitative aspects ([Aaron] Bernstein's *People's Books on Natural Science*, a work of 5 or 6 volumes), a work which I read with breathless attention. I had also already studied some theoretical physics when, at the age of 17, I entered the Polytechnic Institute of Zürich as a student of mathematics and physics." Einstein also recalled that "at the age of 13, I read with enthusiasm Ludwig Büchner's *Force and Matter*, a book which I later found to be rather childish in its ingenuous realism."

On account of business difficulties his father left Munich in 1894 for Milan, but Einstein stayed on in a pension to complete his studies at school. He found the mechanical routine of his academic life at the Gymnasium intolerable, and a few months later he joined his parents in Milan. He had left the unpleasant rigours and discipline of the German gymnasium, but had also left the school in Munich without a diploma. Einstein was fifteen years old.

Einstein spent a year with his parents in Milan, and during this time thought about pursuing higher education in theoretical physics. Having no diploma from the Gymnasium, he thought of gaining admission to the Swiss Federal Institute of Technology in Zurich by taking the entrance examination. Later on, he recalled:

> "As a sixteen year old I came to Zurich from Italy in 1895, after I had spent one year without school and teachers in Milan with my parents. My aim was to gain admission to the Polytechnic, but it was not clear to me how I should attain this, I was a self-willed but modest young man, who had obtained his fragmentary knowledge of the relevant fundamentals [mainly] by self-study. Avid for deeper understanding, but not very gifted in being receptive, studies did not appear to me to be an easy task. I appeared for the entrance examination of the engineering department with a deep-seated feeling of insecurity. Even though the examiners were patient and understanding, the examination painfully revealed to me the gaps in my earlier training. I thought it was only right that I failed. It was a comfort, however, that the physicist H. F. Weber informed me that I could attend his lectures if I stayed in Zurich. The director, Professor Albin Herzog, however, recommended me to the Cantonal School in Aarau, from where after one year's study I was graduated. On account of its liberal spirit and genuine sincerity, and teachers who did not lean on external authority of any kind, this school has left on me an unforgettable impression. Compared to the six years of schooling in an authoritatively run German gymnasium I became intensely aware of how much education leading to independent activity and individual responsibility is to be preferred to the education which relies on drill, external authority, and ambition. Real democracy is not an empty illusion.

" *During this year in Aarau came to me the question: If one follows a light beam with the speed of light, then one would obtain a time-independent wave field. However, such a thing does not exist! This was the first childish thought-experiment which had something to do with the Special Theory of Relativity.* Invention is not the result of logical thinking, even though the final result has to be formulated in a logical manner." (*Author's italics.*)

Einstein tried to imagine what he would observe if he were to travel through space with the same velocity as a beam of light. According to the usual idea of relative motion, it would seem that the beam of light would then appear as a spatially oscillating static electromagnetic field. But such a concept was unknown to physics and at variance with Maxwell's theory. Einstein began to suspect that the laws of physics, including those concerning the propagation of light, must remain the same for all observers however fast they move relative to one another.

When Wertheimer asked Einstein if already at that time he had some idea of the invariance of the velocity of light for all observers in uniform motion, Einstein replied, " No, it was just a curiosity. That the velocity of light could differ depending on the movement of the observers was somehow characterised by doubt. Later developments increased that doubt."

Says Wertheimer: " Light did not seem to answer when one put such questions. Also light, just as mechanical processes, seemed to know nothing of a state of absolute movement or of absolute rest. This was interesting, exciting.

" Light was to Einstein something very fundamental. At the time of his studies at the Gymnasium [Aarau], the aether was no longer being thought of as something mechanical, but as ' the mere carrier of electrical phenomena '. "

Einstein's essay on the state of the aether in magnetic fields presented here (see box), refers to his familiarity with the experiments, and deals rather vaguely with the connection between the aether and electromagnetic phenomena. The problems he thought about at Aarau clearly occurred to him after writing this essay. It is quite possible that sometime during his stay in Munich, Milan, Aarau, or Zurich (that is, during the period 1894 to 1900), or even perhaps in Berne during 1900 to 1905, Föppl's book (to which Holton attaches great importance as a possible influence on Einstein's early work on the relativity theory) fell into Einstein's hands. It is important to emphasise, however, that Einstein does mention Hertz in his essay, and he continued to mention him among his " unforgotten " teachers like Helmholtz, Maxwell, Boltzmann and Lorentz.

[In an undated letter, probably sometime after 6 March 1905, Einstein wrote to his friend Conrad Habicht in Schiers: " But why have you not yet sent me your thesis? Don't you know, you wretch, that I should be one of the few fellows who would read it with interest and pleasure? I can promise you in return four works, the first of which I shall soon be able to send you as I am getting some free copies. It deals with the radiation and energy characteristics of light and is very revolutionary, as you will see if you send me your work in advance. The second study is a determination of the true atomic dimensions from the diffusion and inner friction of diluted liquid solutions of neutral matter. The third proves that on the premise of the molecular theory of induction, particles of the size 1/1000 mm, when suspended in liquid, must execute a perceptible irregular movement which is generated by the movement of heat. Movements of small, lifeless, suspended particles have in fact been examined by physiologists and these movements have been called by them ' the Brownian movement '. *The fourth study is still a mere concept: the electrodynamics of moving bodies by the use of a modification of the theory of space and time. The purely cinematic part of this work will undoubtedly interest you.*" (*Author's italics.*)

The fourth study, to which Einstein refers, was his paper on the Special Theory of Relativity. It was completed in Berne in June 1905, and received by the editor of *Annalen der Physik* on 30 June 1905. It is indeed quite remarkable that even at this late date (sometime after 6 March 1905), Einstein refers to his study as " still a mere concept ". This concept, however, had now been growing within him for almost ten years. On March 11, 1952, Albert Einstein wrote to Carl Seelig: " Between the conception of the idea of this special relativity theory and the completion of the corresponding publication, there elapsed five or six weeks. But [he added rather cryptically] it would be hardly correct to consider this as a birth date, because earlier the arguments and building blocks were being prepared over a period of years, although without bringing about the fundamental decision." Michele Besso, Einstein's friend and colleague at the Patent Office in Berne, was party to the " fundamental decision ", the final progress of Einstein's conception, and its publication. In concluding his paper, Einstein wrote, " I wish to say that in working at the problem dealt with here, I have had the loyal assistance of my friend and colleague M. Besso, and I am indebted to him for several valuable suggestions."]

ROUND-UP OF RESEARCH

Black Holes in the Sky

V. K. KAPAHI

ONE of the interesting consequences of Einstein's theory of relativity pertains to the gravitational influence of very massive bodies. If a given mass is condensed into progressively smaller radii, its gravitational influence becomes so strong that below a critical radius, the radiation emitted by the object can no longer escape from the object. This critical value of the radius, larger for larger masses, is called the Schwarzschild radius, after the German astronomer Karl Schwarzschild who first obtained the solution of Einstein's field equations for a spherical mass in 1916. An object with a radius smaller than the Schwarzschild radius is referred to by astronomers as a ' black hole ' since it cannot be seen by an outside observer.

Because they are cut off from the rest of the universe, black holes have not so far come into the domain of observational astronomy. They have, however, continued to attract the attention of theoreticians, especially after the discovery of ' quasars ' a few years ago and of ' pulsars ' more recently. Quasars are known to be super-massive objects confined within small volumes of space. The large output of energy observed from these objects is believed to be obtained from their gravitational collapse. To release enough energy, it is necessary to consider a collapse close to the singularity associated with the Schwarzschild radius. Some theoreticians feel there is no way of avoiding the collapse of such massive bodies into black holes, while others have wondered if some effects have been overlooked which would invalidate the arguments in favour of an inescapable collapse. The existence of black holes now appears to have been put on a firmer footing by Dr. A. G. W. Cameron of NASA's Goddard Institute for Space Studies, New York. In a recent article in *Nature* (*229*, 178, 15 January 1971), he cites evidence that the companion of the star ε Aurigae in our galaxy must be a black hole or ' collapsar ' as he has termed it.

The star pair ε Aur has long been regarded as a mysterious eclipsing binary system with a period of about 27 years. The primary is a supergiant star of spectral class F2 (corresponding to a surface temperature of around 6,500°C) with a mass of about 35 Suns. The secondary is extremely unusual; although it has a mass of about 23 Suns, it is not visible. During an eclipse, which lasts for nearly 2 years, about half the light of the primary is cut off. It was suggested by Kopal that the system is young; the primary has not yet evolved into the main sequence (stars on the main sequence obtain their energy output from hydrogen burning in their cores, which also stabilises them against collapse) and the secondary is in an even earlier nonluminous state of evolution in the form of a gaseous, dust-filled disc. Cameron rejects this model on several grounds. The heating of the primary should have been readily detectable if it was contracting into the main sequence. Again, a prestellar disc of 23 solar masses should be reasonably luminous. The only alternative is that the primary has evolved off the main sequence. The secondary must have originally been more massive than the present primary and so has evolved much faster, ending up as a collapsar of very small radius, after shedding some of its mass in the ' red giant ' stage.

The eclipse in Cameron's model is caused not by the collapsar itself but by a comparatively light disc of solid dust particles around the collapsar. This disc of absorbing particles, accreted by the stars from interstellar matter, accounts also for the excess infrared radiation which ε Aur is known to emit. Calculations of the dynamics of the system show that solid particles of the size required (about 0·5 cm) would spiral inwards into the collapsar at a rate slow enough to prevent the particles from being swallowed by the collapsar.

In a companion article (*Nature, 229*, 180, 15 January 1971), Dr. R. Stothers, also of the Goddard Institute, has looked for other evidence on the evolutionary stage of the primary of ε Aur on the basis of its association with the star cluster Aur OB1. He concludes that the primary is quite probably in the core helium burning stage, having evolved past the main sequence. The secondary must then almost certainly be a more evolved collapsar. Dr. Stothers goes on to suggest that another supergiant, 89 Hercules, which has recently been found to emit an unexpectedly large flux of infrared radiation, may have an invisible collapsar as its companion.

Indeed there could be many more collapsars in the sky, and not necessarily in binary systems alone. Following these two papers, many exciting developments in this new field of observational astronomy should be forthcoming.

Dr. Kapahi is with the Radio Astronomy Centre, Ootacamund.

Polywater

P. K. MATHUR

POLYWATER has created a controversy in the scientific community. First discovered by a Russian chemist, Prof. Boris Deryagin, polywater is made by condensing water in silica or borosilicate capillary tubes with diameters of 1 to 10 microns. The material produced is stable till 300°C, up to 15 times more viscous than water, has a density of 1·4 gram per cm^3, and has a high refractive index.

Scientists have speculated on its structure. Some have suggested that polywater is a polymer of three centre O — H — O units. A square-like structure with H — O — H units forming two opposite corners, and oxygen with two vacant orbitals forming each of the other two corners is another suggestion. Yet others are of the view that the structure of the substance is analogous with ice II, which has a rhombohedral structure (see SCIENCE TODAY, March 1970).

Scientists have attempted to connect many phenomena like the survival of plants and animals at freezing temperatures with the presence of polywater in these species. It has also been invoked as a mechanism for explaining the pH-reactivity effect in water-cooled nuclear power reactors. Another hypothesis is that the conditions characteristic of the coolant of a pressurised water reactor may permit the formation of polywater. Polywater has also been proposed as the form of water present on Venus; if loosed in the environment, it might serve as a condensing point and turn all water into polywater, destroying all life.

On the other hand, there are scientists who feel polywater is not really a polymer of water; the first analytical data on the subject were presented at a symposium at Lehigh University's first international conference on polywater last June. Dr. Robert L. Davis of Purdue University, USA, and Dr. Dennis L. Rousseau of Bell Telephone Laboratories, USA, have shown by electron spectroscopic chemical analysis (ESCA) that polywater is only a mixture of hard-to-analyse substances leached out of a glass surface.

Scientists report the ESCA of a number of samples of polywater show that these anamolous, viscous, non-volatile materials contain high concentrations (95 per cent or more by weight) of sodium, potassium, sulfate, carbonate, chloride, nitrate, borates and silicates with traces of other impurities containing organic carbon. The samples contain less than 5 per cent water.

Dr. Davis did estimate that the sodium ion spectrum could represent up to 80 per cent of the cations (ions that travel towards the cathode) present in most samples. " Polywater also contains borates and numerous silicates with different degrees of polymerisation. Since both of these are prone to polymerisation, their presence certainly would explain the viscosity and temperature effects reported for polywater samples ", says Dr. Davis. He points out that the presence of aliphatic- and aromatic-type carbon explains why certain polywater samples " burn " on exposure to ruby lasers during Raman studies.

Rousseau and Davis found experimentally that human perspiration, after evaporation to a gummy residue, when analysed on an infrared spectrometer, exhibited spectral characteristics very similar to those of polywater molecules. Analyses conducted by the Soviet Academy of Science's Institute of Chemical Physics on Deryagin's samples of polywater showed that the samples were badly contaminated by organic compounds including lipids and phospholipids which are ingredients of human perspiration.

Davis has an explanation to offer for this type of contamination and is of the view that every person is surrounded by an invisible cloud of organic salts — evaporated from the skin and expelled from the lungs; these may well be absorbed by the porous glass of laboratory wares. Thus polywater, which is made by letting steam condense inside thin capillary tubes, could pick up impurities even in the hands of the most cautious chemist. Davis further points out that attempts to make polywater in polyethylene tubes have invariably failed because polyethylene is comparatively non-porous.

Prof. Deryagin dismisses all these explanations. At the Lehigh University conference he acknowledged that his original specimen may have contained impurities, but once these impurities are removed, polywater continues to exhibit its strange properties. The trouble is that only microgram samples of polywater have been made and, therefore, analyses of samples by more than one technique by several scientists is impossible.

Dr. Mathur is with the Chemistry Division of the Bhabha Atomic Research Centre, Bombay.

Drugs in Labour

K. A. NEELAKANTAN

IN a study on " pain-killing drugs " conducted by Dr. S. E. Fidelma O'Donoghue of the Rotunda Hospital, Dublin, the conclusion reached was that drugs given to the mother in labour during child birth and the compounds produced by the reaction of the mother's metabolism with these drugs are passed on to the newborn baby. The details of this study are reported in *Nature* (*229*, 124, 8 January 1971).

Evidence that the drugs administered to mothers in labour are transferred to the newborn was obtained as early as 1885 when a German doctor, W. Preyer, observed mydriasis (dilation of the pupil of the eye) in newborn children whose mothers had received the herb belladonna. The effect of belladonna is due to the alkaloid atropine which occurs in traces in the plant and has numerous other medically valuable properties in addition to eye dilation. Since then, the search for pain-killing drugs whose effects are not transferred to the foetus through the placenta has been a major concern of obstetricians.

While the search for a drug with minimum adverse effects continues, pethidine (introduced in 1940), usually with other drugs such as chlorpromazine and promazine, is now the most widely used for the relief of labour pains. However, research carried out so far on the suitability of pethidine for obstetrical use has led to unsatisfactory results. In order to provide quantitative data which may be correlated with systematic clinical observations, Dr. O'Doneghue has examined the distribution of pethidine and chlorpromazine and a wide range of their metabolites in the amniotic fluid which surrounds the baby before birth, in the maternal and foetal blood plasma, and in the urine of the mother as well as the newborn baby.

In the experiments described in *Nature*, the drugs in question were given singly or in combination shortly before delivery to 200 women, using intramuscular injections. Samples were then obtained from the mother, the foetus and the newborn baby for experimental study and these were grouped according to the drug delivery interval, i.e. the time taken between administration of the drugs and the delivery. The results were statistically evaluated.

The results indicated that pethidine was found in the amniotic fluid as well as in the blood plasma of the mother and the foetus. Metabolites of pethidine were found in the urine of the mother and the newborn. Chlorpromazine was found in the foetal and maternal plasma and 8 additional metabolites in the amniotic fluid. Chlorpromazine and its metabolites were also isolated from the maternal and neonatal urine. Promazine was found to follow the same pattern of distribution as chlorpromazine.

To understand how the metabolites originated in the urine of the newborn, the Dublin scientist injected pethidine, chlorpromazine and promazine in the newborn from mothers who were not administered these drugs. It was found that the newborn can metabolise these drugs within 24 hours after birth, and the ability for this process increases substantially within the first 72 hours. A comparative study of the compounds found in the urine of the newborn from mothers in whom the drugs were administered and those found in the urine of treated newborn from untreated mothers showed the presence of a number of metabolites in the former which did not appear in the latter. It is obvious that the extra compounds must be of maternal origin and their appearance indicates that the foeto-maternal barrier is permeable not only to the drugs but also to many of their metabolites.

This investigation raises doubt about the safety of using narcotic drugs to relieve labour pains, except in extreme cases. However, the search for an ideal drug and further studies on the relationship between the mother and foetus must continue if a safe drug free from side-effects is to be discovered.

Tropical Forests

BOTANISTS have recognised three types of rain forests on wet tropical mountains. Apart from lowland rain forests, there are two other distinct types of mountain (montane) forests — lower montane and upper montane rain forests. These forest types can be distinguished both by plant associations and by the altitudinal limits within which they lie. It has been found that on small isolated mountains and outlying ridges of major mountain ranges, the upper altitude limit of lowland rain forests is about 700 to 900 metres and that of the lower montane forests about 1,200 to 1,600 metres. However, on mountains that form the main ridges of a chain, the altitude limits of these forest types are approximately 1,200 to 1,500 metres and 1,800 to 2,000 metres respectively. This phenomena in which the mass of forest seems to be shifted in a vertical band is known as the " Massenerhebung " effect.

It has been known for 5 years that the forest types are related to the amount of fog cover. Lower montane rain forests occur where there are short-lived but frequent fogs, whereas the upper montane rain forests are associated with very frequent and more persistent fogs of the central mountains. However, no explanation has so far been given as to why the forests should be correlated with the frequency of fogs. Dr. P. J. Grubb of the Botany School, University of Cambridge, England, one of the first botanists to point out this relation, has now, in an article in *Nature* (*299*, 44, 1 January 1971), explained why fogs should affect the type of forest on tropical mountains.

The English botanist has explained the Massenerhebung effect in terms of the availability of certain minerals like nitrogen and phosphorus to the trees. Previous researches have indicated that the content of organic matter in the soil increases rapidly with altitude, and this increase can follow either from decreasing temperature or from an increase in soil water content. Dr. Grubb now suggests that the water content of the soil is raised during the increase in humidity produced by the fog and this increase slows down the natural processes that convert the organic matter in the soil to minerals. The nitrogen and phosphorous available to the trees must be provided largely by the mineralisation of organic matter and, where the organic matter is not broken down rapidly, the soil is less fertile for plant life.

Due to the above effect, the upper limit of lowland rain forests can be brought down to varying degrees below the temperature-determined altitude limit when the fog characteristics of the lower montane environment occurs at lower levels, because this raises the soil water content and intensifies the slowing down of the mineralisation of organic matter. Similarly, the uppermost limits of the lower montane and upper montane rain forests are set by temperature and they can be brought down to varying degrees by fogs. In short, the main factor causing the Massenerhebung effect is the deficiency of minerals due to the persistence of fogs at certain altitudes.

Dr. Neelakantan is with the Department of Atomic Energy, Bombay.

Hair Transplants

S. K. PANDYA

BALDNESS is a universal problem that plagues not a few males and quite a few females as well. To be told that each individual hair follicle is genetically predisposed over a period of time to respond to androgenic influences that inhibit, stimulate or do not affect its growth does not bring much comfort to the individual with the receding hairline! Nor does it help to know that the beard, axillary, pubic, chest and limb hair are actually stimulated by androgens! We learn with dismay that the front, top and adjacent sides of the scalp are particularly vulnerable to these male hormones hereditarily, whilst the fringes and back of the scalp are unaffected. The availability of wigs notwithstanding, the baldie views the future with gloom.

A recently published review on hair transplantation should give these individuals hope. The author reports an almost 100 per cent success in his patients, some of them followed up for over 15 years.

Simply, the transplant is a surgical procedure carried out by experts in that branch of surgery called ' plastic surgery '. It involves transferring hair from the persistent fringe and back of the scalp reservoirs to the cosmetically more significant front. The selection of the patients is important. The surgeon has to consider carefully the donor and recipient areas, the expectations of the patient, the most satisfactory hair style that he can reasonably promise, the number of grafts that will be required, the financial aspects and the time factor. It is important for the patient to realise that the transplantation is a long drawn out process and involves a certain amount of temporary inconvenience.

After having planned his operations, the surgeon cleanses the donor and recipient areas with 70 per cent alcohol. The donor hair is clipped (not shaved) up to a length of 2 mm above the scalp, and he carefully notes the direction of hair growth. After injecting a local anaesthetic, the surgeon takes out 2 to 4 mm skin pieces from the hairy parts, each skin piece containing 12 to 15 hairs. Usually 10 to 50 such pieces are cut out at each sitting. These skin pieces are then transferred to the bald areas, where raw areas of the same sizes have been created. Once the donor skin pieces have been placed in their new beds, a pressure dressing is applied. The skin pieces are soon firmly anchored by fibrin clots. A gentle shampoo five days later gets rid of most of the scabs. Complete healing takes approximately 15 days.

In successive sittings, more and more such grafts are made till the required results are obtained. The surgeons emphasise that initially the transplanted hair dwindles and may even fall away, but that this is only temporary. Reforestation occurs soon.

Whereas hitherto only the same individual's hair could be transplanted, over the past year experiments using hair from other individuals have been successful, provided local triamcinolone injections were made every 30 days. Apparently this takes care of the immune response.

Dr. Pandya is an assistant neuro-surgeon in the K.E.M. Hospital, Bombay.

BLURS & BRIGHT SPOTS

And now 'light pollution'!

THE problem is not really ecological. A brightly-lit city makes her citizens happy. Except the astronomers. And astronomers are really becoming a disgruntled breed: cities nearabout the observatories throw out so much glare on to their night skies that it is becoming impossible to see the heavens. The problem has come to the fore in Tuscon, Arizona, USA, where the mountains surrounding the city house five world-famous observatories: Kitt Peak National Observatory, The National Radio Astronomy Observatory, Steward Observatory, the Lunar and Planetary Laboratory and the Smithsonian Institution's Astrophysical Observatory. The Tuscon stargazers, according to *Science* (5 February 1971), are going in for a fight all the way.

According to Arthur Hoag, Associate Director of the Stellar Division at Kitt Peak National Observatory, " two types of light from a city's outdoor lighting bother astronomers: ultraviolet light and general glare, and both are scattered in the air by particulate matter (there comes air pollution again!). The ultraviolet light comes mainly from mercury vapour lamps which are used in most cities for street lights. And most of an observatory's instruments are particularly sensitive to ultraviolet light; also some of the most interesting spectral emissions from the stars occur at precisely those wavelengths that are obscured by the ultraviolet light from mercury vapour lamps. The second problem is glare from all types of light which lightens the sky making it difficult to view faint objects such as distant galaxies. "

Hoag and his colleagues went to the Tuscon City Council with a proposal (they had to study a whole lot of nonastronomical subjects like light engineering and city planning): Tuscon should cut down its night-time glare. They suggested two ways this could be done — by placing shields over all outdoor lighting to direct the light towards the ground, thus reducing glare in the sky, and by installing filters over mercury vapour lamps to screen out the ultraviolet light. They have a sound economic reason to back their argument: over $60 million have been invested in the five Tuscon area observatories which together spend more than $12 million annually to run themselves; this makes ground-based astronomy one of Tuscon's major industries.

Why build observatories so near the cities? some may ask. Ideally, astronomers would prefer to work in the wilderness where the sky remains dark and free from air pollution. But the need for supplies and technical assistance forces them to build near civilisation. The other reason is that when the observatories were built, the planners had not foreseen the phenomenal growth of population centres. In that respect, Tuscon is not the only aggrieved spot. Mount Wilson Observatory, built on a slope overlooking a sleepy southern California town called Los Angeles in 1916, became useless for observing some phenomena as early as 1930; today the situation is worse. The same goes for the University of California's Lick Observatory. Robert P. Craft, its acting Director, says: " Lick will be out of the business of observing galaxies, quasars and other faint objects within a decade ". The cause: the nearby city of San Jose.

Tucson's light pollution, photographed from Kitt Peak

Are the astronomers fighting a losing battle? Will the cities agree to pare off part of their dazzle? Nobody can tell. The owners of a dog track near the Smithsonian Institution's Mount Hopkins Observatory willingly cooperated by shielding its lights and later found that their customers could see the races better. Others may not be as willing, especially if they need the lights to sell their wares. Owners of used car lots, for example. Filters installed over mercury vapour lamps make everything under them appear yellow.

Analysis of 62 advances since 1900 shows that most come from a few centres and have rapid effects

Conditions Favouring Major Advances in Social Science

KARL W. DEUTSCH, JOHN PLATT & DIETER SENGHAAS

THE environmental group conditions for creative success in the social sciences are a frequent subject for debate. It is not generally realised how much information about these creative conditions can be obtained from a statistical analysis of creative instances. To examine this question, we made a list of some 62 leading achievements in the social sciences in this century (see Table 1). With this list we have tried to explore the following major groups of questions.

1. Which were the major achievements, or advances, or breakthroughs in the social sciences from 1900 to 1965? Are there publicly verifiable criteria by which they can be recognised? Can such advances be called cumulative in the sense proposed by J. B. Conant — that is, have successive advances been built upon earlier ones?

2. In what fields did such breakthroughs occur?

3. Did major advances relate mainly to theory, or to method, or to matters of substance? In what fields did such advances occur most often?

4. Are there any changes and trends over time in the incidence and characteristics of these breakthroughs?

5. Who accomplished such advances most often — individuals or teams?

6. What were the ages of the contributors at the time of their achievements? Did they have any special personality characteristics?

7. Were the results quantitative, explicitly or by implication?

8. Did such breakthroughs require much capital? Manpower? Other resources?

9. Where were they accomplished? At what geographic locations? At what types of institutions? Under what social and political conditions?

10. Where did the ideas come from? Were most advances made primarily within existing disciplines, or were they mainly interdisciplinary in character?

11. Did the major advances have any close relation to social practice? Were they inspired or provoked by practical demands or conflicts? Were they applied to practice? If so, were they applied by or to individuals, small or middle-sized groups, or national governments and states?

This article first appeared in "Science", Vol. 171, February 1971, pp. 450-457. Copyright 1971 by the American Association for the Advancement of Science.

12. How long was the delay between each major breakthrough and its first major impact on social science or social practice, or both?

Some of the evidence bearing on these questions are summarised in Table 1 in relation to the 62 achievements in the years 1900–65. The achievements themselves were selected on the basis of our personal judgment as to their importance for social science in this century. We also called upon the opinions and advice of a number of colleagues in other fields, and we checked each contribution against the relevant entries of the recent edition of the *International Encyclopaedia of the Social Sciences.*

The full range of answers to our questions, including various kinds of statistical analyses, will be given elsewhere, but some of the broad results of more general interest are summarised here. There are three principal findings from this study: (*i*) There are such things as social science achievements and social inventions, which are almost as clearly defined and as operational as technological achievements and inventions. (*ii*) These achievements have commonly been the result of conscious and systematic research and development efforts by individuals or teams working on particular problems in a small number of interdisciplinary centres. (*iii*) These achievements have had widespread acceptance or major social effects in surprisingly short times; median times are in the range of 10 to 15 years, a range comparable with the median times for widespread acceptance of major technological inventions.

Criteria for recognising major advances in social science

The major achievements or breakthroughs selected for this study were defined as having the following characteristics. First, they either had to involve a new perception of relationships or they had to result in new operations, including scientific operations. That is, they had to help people see something not perceived before, as represented by new discoveries (statements of the form " there is . . . ") or new verifiable propositions (statements of the form " if . . . then . . . "); or else they had to create the possibility of doing something that had not been done before.

A second essential condition for any major contribution, whether of perceptions or of operations, was that it should have proved fruitful in producing a substantial impact that led to further knowledge. Impacts simply upon social practice were treated as interesting but nonessential.

We believe that the 62 contributions listed in Table 1 are among the most significant achievements in social science that satisfy these criteria in the years 1900–65. We should emphasise that there is no intent to use this list for any invidious bestowal of professional recognition and that other achievements might well be chosen by other criteria of significance or for other purposes.

We omitted purely technical achievements such as television, in spite of their great impact on society, in the belief that they have thus far not contributed to social science in the way, for instance, that computers have. We also omitted the more purely political and organisational achievements, such as the National Aeronautics and Space Administration (NASA), the Manhattan Project, the British National Health Service, the European Common Market, the Tennessee Valley Authority, credit cards, " think tanks ", the great public and private foundations, the Peace Corps, and the partial Nuclear Test Ban Treaty, although all these have intellectual components that would justify their inclusion in a broader list. On the same grounds, we omitted such primarily practical innovations as Henry Ford's development of the assembly line; the time and motion studies by F. W. Taylor and his followers; the studies of human relations in industry by F. J. Roethlisberger and his associates; the development of such rural organisations as the *kibbutzim* in Israel and the *kolkhozy* in the Soviet Union; B. Ruml's invention of the " pay-as-you-go income tax "; the development of high-information teaching by J. Zacharias and associates; man-and-computer designs as developed by C. E. Shannon, R. Fano, and others; and the proposal for a guaranteed annual income, or a negative income tax, by J. Tobin, M. Friedman, and other economists. By contrast, the innovations by Lenin, Mao, Gandhi, and the Webbs were included because they were connected with explicit theories.

Several contributions seemed to us to constitute borderline cases. In social psychology, these include the frustration-aggression hypothesis by J. Dollard, N. Miller and their collaborators (New Haven, Connecticut, 1940); the theory of cognitive dissonance developed by L. Festinger, R. Abelson and others (Stanford, California, and New Haven, 1956–57); the development of cognitive anthropology by F. Lounsbury and others (New Haven, 1956–68); the concept and measurement of the semantic differential by C. Osgood, G. J. Suci, and P. H. Tannenbaum (Urbana, Illinois, 1957); and the concept and partial measurement of achievement motivation by D. E. McClelland (Middletown, Connecticut, 1953, and later Cambridge, Massachusetts, 1961). At the borderlines of psychology, we find the discovery of a wider range of mind-influencing drugs; the works of K. Lorenz and others on " imprinting " in young animals; the broader explorations in the chemistry

TABLE 1. BASIC INNOVATIONS IN SOCIAL SCIENCE, 1900-65. ABBREVIATIONS IN COLUMN 1: AN, ANTHROPOLOGY; EC, ECONOMICS; MATH, MATHEMATICS; PHIL, PHILOSOPHY, LOGIC, AND HISTORY OF SCIENCE; POL, POLITICS; PSY, PSYCHOLOGY; SOC, SOCIOLOGY. IN COLUMN 6, + N INDICATES A LARGE NUMBER OF COLLABORATORS WITH A LESS CRUCIAL SHARE IN THE WORK. ABBREVIATIONS IN COLUMN 7: QFE, QUANTITATIVE FINDINGS EXPLICIT; QPE, QUANTITATIVE PROBLEMS EXPLICIT; QPI, QUANTITATIVE PROBLEMS IMPLIED; NON-Q, PREDOMINANTLY NONQUANTITATIVE

Contribution 1	Contributor 2	Time 3	Place 4	Type of support 5	No. of workers 6	Quantitative aspects 7	Years until impact 8
1. Theory and measurement of social inequalities (Ec)	V. Pareto C. Gini	1900 1908	Lausanne, Swit. Cagliari, It. Padua, It. Rome, It.	University chairs	1 + N	QFE	25
2. Sociology of bureaucracy, culture, and values (Soc)	M. Weber	1900–21	Freiburg, Ger. Heidelberg, Ger. Munich, Ger.	University chair with research support	1	QPI	20 ± 10
3. Theory of one-party organisation and revolution (Pol)	V. I. Lenin	1900–17	Shushenskoe, Siberia London, Eng. Munich, Ger.	Underground party	1 + N	QPI	10 ± 5
4. Psychoanalysis and depth psychology (Psy)	S. Freud C. G. Jung A. Adler	1900–25 1910–30 1910–30	Vienna, Aus.	University institute of psychology	1 + N	Non-Q	30 ± 10
5. Correlation analysis and social theory (Math)	K. Pearson F. Edgeworth R. A. Fisher	1900–28 1900–30 1920–48	London, Eng. Oxford, Eng. Cambridge, Eng. Harfenden, Eng.	University chairs	1 + N	QFE	25 ± 15
6. Gradual social transformation (Pol)	B. Webb S. Webb G. B. Shaw H. G. Wells	1900–38	London, Eng.	Fabian society	4 + N	QPE	35 ± 5
7. Elite studies (Soc)	G. Mosca V. Pareto H. D. Lasswell	1900–23 1900–16 1936–52	Turin, It. Lausanne, Swit. Chicago, Ill.	University institutes	1 + N	QFE	40 ± 10
8. Unity of logic and mathematics (Phil)	B. Russell A. N. Whitehead	1905–14	Cambridge, Eng.	University institute	2	QPE	30
9. Pragmatic and behavioral psychology (Psy)	J. Dewey G. H. Mead C. Cooley W. I. Thomas	1905–25 1900–34 1900–30 1900–40	Ann Arbor, Mich. Chicago, Ill. Ann Arbor, Mich. Chicago, Ill. New York, N.Y.	University chairs	1	Non-Q	20 ± 10
10. Learning theory (Psy)	E. L. Thorndike C. Hull *et al*	1905–40 1929–40	New York, N.Y. New Haven, Conn.	Teachers college, Institute of human relations	1 + N	QFE	20 ± 5

Contribution 1	Contributor 2	Time 3	Place 4	Type of support 5	No. of workers 6	Quantitative aspects 7	Years until impact 8
11. Intelligence tests (Psy)	A. Binet L. Terman C. Spearman	1905–11 1916–37 1904–27	Paris, Fr. Stanford, Calif. London, Eng.	Testing organisations	1 + N	QFE	15 ± 5
12. Role of innovations in socio-economic change (Ec)	J. A. Schumpeter W. F. Ogburn A. P. Usher J. Schmookler	1908–14 1946–50 1922–30 1924 1966	Vienna, Aus. Cambridge, Mass. New York, N.Y. Cambridge, Mass. Minneapolis, Minn.	University chair and research programme	1 + N	QPI	40
13. Conditioned reflexes (Psy)	I. Pavlov	1910–30	Leningrad, U.S.S.R.	Imperial medico-surgical academy	1 + N	QPI	20 ± 10
14. Gestalt psychology (Psy)	M. Wertheimer K. Koffka W. Koehler	1912–32	Berlin, Ger.	University chairs	3 + N	Non-Q	25 ± 5
15. Sociometry and sociograms (Soc)	J. L. Moreno	1915 1934–43	Innsbruck, Aus.	University chair	1	QFE	10
16. Soviet type of one-party state (Pol)	V. I. Lenin *et al*	1917–21	Leningrad, U.S.S.R.	Politburo	1 + N	QPI	5 ± 5
17. Large-scale nonviolent political action (Pol)	M. K. Gandhi	1918–34	Ahmedabad, India	Political movement and institute (ashram)	1 + N	Non-Q	15 ± 10
18. Central economic planning (Ec)	Q. Krassin G. Grinko	1920–26	Moscow, U.S.S.R.	Government institute	1 + N	QFE	7 ± 6
19. Social welfare function in politics and economics (Ec)	A. C. Pigou K. Arrow	1920–56 1951	London, Eng. Stanford, Calif.	University chairs	1 + N	QPE	40 ± 10
20. Logical empiricism and unity of science (Phil)	M. Schlick R. Carnap O. Neurath P. Frank L. Wittgenstein H. Reichenbach C. Morris	1921–38 1921 1936–50	Vienna, Aus. Cambridge, Eng. Berlin, Ger. Chicago, Ill. Cambridge, Mass.	Vienna circle and university chairs University chairs	3 + N	QPI	20 ± 5
21. Quantitative mathematical studies of war (Pol)	L. F. Richardson Q. Wright	1921–55 1936–66	London, Eng. Chicago, Ill.	University chair and research programme	1 + N	QFE	25 ± 10
22. Projective tests (Psy)	H. Rorschach H. Murray	1923	Herisau, Swit. Cambridge, Mass.	Cantonal mental institute University chair	1	Non-Q	15 ± 5

Contribution 1	Contributor 2	Time 3	Place 4	Type of support 5	No. of workers 6	Quantitative aspects 7	Years until impact 8
23. Sociology of knowledge science (Soc)	K. Mannheim R. K. Merton D. deS. Price	1923–33 1937 1950–60	Heidelberg, Ger. Frankfurt, Ger. Princeton, N.J. New Haven, Conn.	University chairs, institutes, and programmes	1 + N	Non-Q	10
24. Quantitative political science and basic theory (Pol)	C. Merriam S. Rice H. Gosnell H. D. Lasswell	1925–36	Chicago, Ill.	University chairs	3 + N	QFE	15 ± 5
25. Functionalist anthropology and sociology (An)	A. R. Radcliffe-Brown B. Malinowski T. Parsons	1925 1925–45 1932–50	Cape Town, S. Afr. Sidney, Aus. Chicago, Ill. Oxford, Eng. London, Eng. Cambridge, Mass.	University chairs and travel grants	1 + N	Non-Q	20 ± 10
26. Ecosystem theory (Soc)	R. Park E. W. Burgess	1926–38	Chicago, Ill.	University chairs	2 + N	QFE	25 ± 5
27. Factor analysis (Math)	L. Thurstone	1926–48	Chicago, Ill.	University chair	1 + N	QFE	15 ± 10
28. Operational definitions (Phil)	P. W. Bridgman	1927–38	Cambridge, Mass.	University chair	1	QPI	15 ± 5
29. Structural linguistics (Math)	R. Jakobson and Prague circle N. Chomsky	1927–67 1957–	Brno, Czech. Cambridge, Mass. Cambridge, Mass.	University chairs and programmes	1 + N	QPE	20 ± 10
30. Economic propensities, employment, and fiscal policy (Ec)	J. M. Keynes	1928–44	Cambridge, Eng.	University chair	1 + N	QFE	6 ± 4
31. Game theory (Math)	J. V. Neumann O. Morgenstern	1928–44 1944–58	Berlin, Ger. Princeton, N. J.	University chairs and institute	2 + N	QFE	10 ± 5
32. Peasant and guerilla organisation and government (Pol)	Mao Tse-tung	1929–49	Kiangsi, P. R. China Yenan, P. R. China Peking, P. R. China	Political movement	1+ N	QPI	15 ± 10
33. Community studies (Soc)	R. Lynd H. Lynd L. Warner C. Kluckhohn	1929–62 1941	New York, N.Y. Chicago, Ill.	University chairs	2	QFE	20 ± 5

Contribution 1	Contributor 2	Time 3	Place 4	Type of support 5	No. of workers 6	Quantitative aspects 7	Years until impact 8
34. Culture and personality and comparative child rearing (An)	R. Benedict M. Mead G. Gorer A. Kardiner J. Piaget E. Erikson J. Whiting I. Child	1930 1930 1939 1940–60 1950 1953	New York, N.Y. Geneva, Swit. Cambridge, Mass. Cambridge, Mass. New Haven, Conn.	University chairs, research projects, and travel grants	3 + N	Non-Q	20 ± 10
35. Economics of monopolistic competition (Ec)	E. H. Chamberlin J. Robinson	1930–33	Cambridge, Mass. Cambridge, Eng.	University chairs	1	QPE	10 ± 5
36. Authoritarian personality and family structure (Psy)	M. Horkheimer H. Marcuse E. Fromm T. Adorno *et al* A. Mitscherlich	1930–32 1950 1962	Frankfurt, Ger. Stanford, Calif. Frankfurt, Ger. Heidelberg, Ger.	Institute for social research and university	3 + N	QPI	20 ± 5
37. Large-scale sampling in social research (Math)	M. Hansen	1930–53	Washington, D.C.	Government office	N	QFE	5
38. Laboratory study of small groups (Psy)	K. Lewin R. Lippitt R. Likert D. Cartwright	1932–36	Cambridge, Mass.	University and research institutes	1 + N	QPI	10 ± 5
39. National income accounting (Ec)	S. Kuznets C. Clark U.N. Statistical Office	1933–40 1953	Philadelphia, Pa. Cambridge, Eng. Washington, D.C. New York, N.Y.	Public research institutes and university chairs	1 + N	QFE	10 ± 5
40. General systems analysis (Phil)	L. V. Bertalanffy N. Rashevsky J. G. Miller A. Rapoport R. W. Gerard K. Boulding	1936 1956	Vienna, Aus. Chicago, Ill. Ann Arbor, Mich.	University research institutes	4 + N	QPI	15 ± 5
41. Attitude survey and opinion polling (Psy)	G. Gallup H. Cantril P. F. Lazarsfeld A. Campbell	1936 1937–52 1940 1942	Princeton, N.J. New York, N.Y. Ann Arbor, Mich.	University and research institutes, commercial organisations	3 + N	QFE	5
42. Input-out analysis (Ec)	W. Leontief	1936–53	Cambridge, Mass.	University chair	1 + N	QFE	15

Contribution 1	Contributor 2	Time 3	Place 4	Type of support 5	No. of workers 6	Quantitative aspects 7	Years until impact 8
43. Linear programming (Ec)	L. Kantorovich J. B. Souto G. B. Dantzig R. Dorfman	1938–50 1941 1948 1958	Leningrad, U.S.S.R. Buenos Aires, Arg. Washington, D.C. Berkeley, Calif.	University research institute and government office	1 + N	QFE	10 ± 5
44. Content analysis (Pol)	H. Lasswell I. deS. Pool B. Berelson P. Stone	1938–56 1961–66	Chicago, Ill. Cambridge, Mass.	University institute	2	QFE	10
45. Operant conditioning and learning; teaching machines (Psy)	B. F. Skinner	1938–58	Bloomington, Ind. Cambridge, Mass.	University chairs	1 + N	QPE	15
46. Statistical decision theory (Math)	A. Wald	1939–50	New York, N.Y.	University chair	1 + N	QPE	15 ± 5
47. Operations research and systems analysis (Math)	P. M. S. Blackett P. Morse R. Bellman	1941-50 1941–58	London, Eng. Cambridge, Mass.	Government research institutes	N	QPE	5
48. Scaling theory (Psy)	L. Guttman C. Coombs	1941-54	Ithaca, N.Y. Ann Arbor, Mich.	University chairs	3 + N	QFE	10 ± 5
49. Quantitative models of nationalism and integration (Pol)	K. Deutsch B. Russett R. L. Merritt	1942–67	Cambridge, Mass. New Haven, Conn.	University chairs	1 + N	QFE	20 ± 5
50. Theories of economic development (Ec)	P. Rosenstein-Rodan R. Prebisch R. Nurkse W. A. Lewis G. Myrdal A. O. Hirschman R. F. Harrod E. Domar H. Chenery	1943–58	London, Eng. Santiago, Chile New York, N.Y. Manchester, Eng. Stockholm, Swed. New Haven, Conn. Oxford, Eng. Baltimore, Md. Stanford, Calif.	Government offices, U.N. regional commission, university chairs	6 + N	QFE	10 ± 5
51. Computers (Math)	V. Bush S. Caldwell D. P. Eckert J. W. Mauchly	1943–58	Cambridge, Mass. Philadelphia, Pa.	University and government research laboratories	N	QFE	10 ± 5
52. Multivariate analysis linked to social theory (Soc)	S. Stouffer T. W. Anderson P. Lazarsfeld	1944–54	Washington, D.C. Cambridge, Mass. New York, N.Y.	Government and university research institutes	3 + N	QFE	5

Contribution 1	Contributor 2	Time 3	Place 4	Type of support 5	No. of workers 6	Quantitative aspects 7	Years until impact 8
53. Information theory, cybernetics, and feedback systems (Math)	C. Shannon N. Wiener	1944–58	Cambridge, Mass. Orange, N.J.	University research institute and Bell Laboratories	2 + N	QFE	10 ± 5
54. Econometrics (Ec)	J. Tinbergen P. Samuelson E. Malinvaud	1935–40 1947 1964	The Hague, Neth. Cambridge, Mass. Paris, Fr.	Government institute and university chairs	1 + N	QFE	10 ± 5
55. Cognitive dynamics of science (Phil)	J. B. Conant I. B. Cohen T. Kuhn D. deS. Price	1946–64	Cambridge, Mass. Berkeley, Calif. New Haven, Conn.	University chairs	3 + N	Non-Q	15
56. Computer simulation of economic systems (Ec)	L. Klein G. Orcutt	1947–60	Philadelphia, Pa. Madison. Wis.	Research institutes	2 + N	QFE	5
57. Structuralism in anthropology and social science (An)	C. Levi-Strauss	1949–66	Paris, Fr.	Museum (government)	1 + N	QPI	15 ± 5
58. Hierarchical computerized decision models (Math)	H. Simon	1950–65	Pittsburgh, Pa.	University research institute	1 + N	QPE	10
59. Cost-benefit anaylsis (planned programming and budgeting) (Pol)	C. Hitch	1956–63	Santa Monica, Calif.	Government-related research institute	3 + N	QFE	7
60. Computer simulation of social and political systems (Pol)	W. McPhee H. Simon A. Newell I. Pool R. Abelson	1956–66 1958–64	Pittsburgh, Pa. Cambridge, Mass. New Haven, Conn.	University chairs and research institutes	2 + N	QPE	5 ± 3
61. Conflict theory and variable sum games (Psy)	A. Rapoport	1960–	Ann Arbor, Mich.	University research institute	1 + N	QFE	2
62. Stochastic models of social processes (Math)	J. S. Coleman	1965	Baltimore, Md.	University and research institute	1 + N	QFE	5

of memory; and the work on the electric stimulation on brain centres directing larger sequences of behaviour, by J. Delgado and others. None of these have been included in our present list, primarily because we were not sure that the impact of any of these contributions on broader areas of the social sciences has been as large and lasting, so far, as the impact of the contributions that we did include. A future tabulation may well have to include some or all of these present-day borderline cases. In any case, a comparison with our tables in this article will show that an inclusion of these borderline cases would have strengthened rather than weakened the trends indicated by our major findings.

Clearly, other individuals and other schools of thought would have a different ranking for particular achievements, but one would hope that within our chosen boundaries there would be a considerable amount of overlap within the academic community in evaluating the top 50 to 70 contributions in this century.

An inspection of our list shows that many of the later contributions were clearly building on the earlier ones, and that they resulted in clear increases in the powers of social scientists to recognise relationships and to carry out operations. Many of the advances had a substantial impact on the subsequent development of several social sciences and on social practice as well. Together these advances add up to unmistakable evidence of the cumulative growth of knowledge in the social sciences in the course of this century. Today, statements such as " we know no more about human psychology and politics than Aristotle did " mainly express the ignorance of these who utter them.

Main fields of advances

The assignment of major social science innovations to particular fields is indicated in column 1 of Table 1, and their distribution among fields is shown in column 1 of Table 2. Table 2 reveals the leading position of psychology, economics, and politics with 13, 12, and 11 major contributions, respectively. On the average, therefore, a major advance was made every 5 or 6 years in each of these fields.

Several contributions that involve the applications of mathematical and statistical methods to these subject fields are included in these numbers; thus linear programming and the computer simulation of economic systems were each coded as contributions to economics.

There were 11 major contributions that were primarily mathematical or statistical in nature but that were coded in a separate category, even though they may have had applications in various substantive fields. Factor analysis and information theory are two examples of this category. Although these coding rules tend to underrepresent the number of major advances in social science methods, it still appears that a major advance in mathematical or statistical method was made on the average at least once every 6 years.

Substantive advances in sociology seemed to have occurred once per decade, and in anthropology about once every 20 years. These calculations somehow underrepresent, however, the actual rate of progress in these fields, particularly with regard to sociology. Several of the advances in social psychology, political science, and even economics were almost as important for the progress of sociology as they were in their fields of origin.

Another five contributions resemble those in mathematics and statistics in that their primary impact was not in any substantive fields of social science. Since they were not primarily quantitative, however, we coded them in a separate category as philosophy, logic, and history of science. Russell and Whitehead's demonstration of the unity of logic and science, the work of the Vienna circle on the unity of science, and Kuhn's work on the role of paradigms in scientific revolutions are examples of such entries.

Theory, method, or substance?

Important advances typically combine theory, methods, and results, rather than choosing one of these elements as a focus of interest. Our analysis of these factors is summarised in Table 2. Most often such advances have cut across at least two of these aspects of social science and have often crossed all three of them. In the light of these findings the long-standing quarrel about whether to emphasise theory, methodology, or empirical results seems ill-conceived and obsolete. All three seem to form part of one production cycle of knowledge, and substantial advances in any one of these three phases are likely to lead to advances in the other two.

Trends with time

Substantial social science advances at the level of importance examined here have been surprisingly frequent, averaging close to one advance per year. When we take into account the greater difficulty of estimating the full impact of social science contributions after 1950, which drastically reduces the number of such contributions in our count, it seems that this high frequency has remained at least undiminished since 1930. Social science investigators who need to keep informed in several disciplines thus face serious problems in the partial obsolescence of their information.

TABLE 2. MAJOR SOCIAL SCIENCE CONTRIBUTIONS BY FIELD AND FOCUS, 1900 TO 1965

Field	*Total*	*Major contributions*		*Focus on theory*		*Focus on method*		*Focus on results*	
	1900 to 1965	1900 to 1929	1930 to 1965	1900 to 1929	1930 to 1965	1900 to 1929	1930 to 1965	1900 to 1929	1930 to 1965
Psychology	13	7	6	6	3	6	6	6	6
Economics	12	5	7	4	5	4	6	5	7
Politics	11	7	4	7	2	2	4	4	4
Mathematical statistics ..	11	4	7	2	5	4	7	4	6
Sociology	7	6	1	4	1	5	1	6	1
Philosophy	5	3	2	3	2	2	2	0	1
Anthropology	3	1	2	1	2	0	2	1	2
Total	62	33	29	27	20	23	28	26	27

A more detailed analysis indicates that the distribution of advances shows a certain amount of clustering in time. Particular fields show " great periods " of 5 to 15 years during which substantial advances were frequent, and two such great periods, 1925-29 and 1940-44, are common to many fields. (If several promising contributions that we considered but did not include in our count should prove to be fundamental, then the decade 1955-65 may yet prove to have been another period of greatness.) Since great periods often last several years, whereas 10 to 15 years may be required for working out the implications of particular achievements or for applying them to practice (Table 1, column 8), it would seem rational to organise 10- or 15-year programmes of support in any social science field after a few initial breakthroughs have occurred.

Individuals or teams?

Individual researchers produced nearly two-thirds of all major advances over the entire 1960–65 period, but our study indicates that their share declined from about three-quarters of all contributions before 1930 to less than one-half thereafter (Table 1, column 6). Teams of social scientists, by contrast, increased their contributions from less than one-quarter before 1930 to more than one-half thereafter. Teams of social scientists seem likely to be the main source of major advances during the next decade, but individual social scientists operating in the traditional " great man " or " lone wolf " styles will continue to be a significant, though secondary, source of new ideas.

Ages of the contributors

The ages of the contributors at the time they made their breakthroughs have also been examined. Details of the analysis will not be given here, but for the entire period 1900–65, the median age group among 160 contributors was between 35 and 39 years, with a mean of 37 years. The modal age group, with 40 contributors, was a little older, in the range of 40 to 44 years. Slightly more than 40 per cent of all contributors were more than 40 years old at the time of their contribution, but only 16 per cent were over 50 years. The psychologists tend to be somewhat younger, the sociologists and anthropologists somewhat older, than the contributors in the other fields.

Since 1930 the contributors tend to be younger, with the modal age moving to the 30 to 34 age group. However, this could be an artifact, due to our better knowledge of the earlier stages of more recent developments. It also seems that the youngest contributors are in the fields with the largest number of contributors. Conceivably some fields are intrinsically more difficult today and require more experience for any success.

It is worth emphasising that older scientists are necessarily less numerous in any rapidly growing field, as D. Price has noted. Since the number of social scientists grew between 1900 and 1965 at a rate of about 5 per cent per year, doubling every 14 years, the proportion of scientists in the age groups 20 to 34, 35 to 49, and 50 to 64 at any given time is roughly as 4 : 2 : 1. When the creativity

TABLE 3. CAPITAL REQUIREMENTS AND QUANTITATIVE RESULTS, 1900 TO 1965. ("HIGH" AND "LOW" REFER TO THE LEVEL OF CAPITAL REQUIRED)

Type of result	1900 *to* 1929		1930 *to* 1965		1900 *to* 1965	
	High	*Low*	*High*	*Low*	*High*	*Low*
Nonquantitative results	1	6	0	2	1	8
Applications to quantitative problems explicit and/or implied	3	9	4	5	7	14
Quantitative findings explicit	4	10	14	4	18	14
Total	8	25	18	11	26	36

curves are normalised to take account of these differences in numbers, the creativity of men over 50 for social science achievements of this sort is comparable to that of the men under 35, but the mode is still in the 35- to 49-year range.

Our findings on the ages of peak creativity in these fields are in fair agreement with those of H. C. Lehman for the fields of architecture, psychology, economics, and education theory.

Our biographical information is uneven and incomplete, but it suggests that the key members of the post-1930 teams were not colourless cogs in an anonymous machine. Usually we find among them strong and highly individualistic personalities, with some of the strengths and weaknesses found in the personalities of artists. Often they have appeared to some of their contemporaries as " rude and overbearing men," impatient with disagreement and obtuseness and unwilling to suffer fools or critics gladly. The decisive difference from the past is that today these creative individuals nonetheless know how to work with other people, how to support others, and how to elicit their cooperation and support in turn. Indeed, a surprising number of them founded significant organisations or institutes to carry on their work.

Are the great achievements quantitative or nonquantitative?

Quantitative problems or findings (or both) characterised two-thirds of all advances, and five-sixths of those were made after 1930 (Table 1, column 7). Completely nonquantitative contributions — the recognition of new patterns without any clear implication of quantitative problems — were rare throughout the period and extremely rare since 1930. Nonetheless, they include such substantial contributions as psychoanalysis, Rorschach tests, and the work on personality and culture; thus, their potential for major contributions in the future should not be underrated. Certainly both types of scientific personalities, the quantifiers and the pattern-recognisers — the " counters " and the " poets " — will continue to be needed in the social sciences.

Requirements in capital, man-power, and time

The making and testing of any new discovery require some kind of investment in the form of capital equipment, man-power, or the principal investigator's time. Libraries represent relatively low capital requirements per investigator, but special laboratories, computing facilities, and organisations for survey or implementation represent high capital requirements.

In man-power, the extremes are represented by a single scientist working at a desk, or by the need for large numbers of laboratory assistants, polltakers, or tabulating clerks. In time, some achievements may require relatively short periods of insight and working out, whereas others require years of the principal investigator's time and thought, as did Max Weber's historical and sociological studies or Freud's development of psychoanalysis. We have coded each contribution in terms of these three types of requirements and analysed their distributions.

Of particular interest was the difference in high and low capital requirements for the quantitative and the nonquantitative contributions, as summarised in Table 3. Here we find that out of 26 high capital contributions during the entire period, 18 produced explicit quantitative findings, whereas out of 36 contributions with low capital requirements, only 14 produced such explicit quantitative results. There was already a tendency toward higher capital requirements for quantitative work in the 1900–29 period, but it becomes considerably stronger after 1930 as high capital work has become more frequent.

The perception of social science work as cheap — a notion that is widespread among laymen and some university administrators — seems based on the experiences before 1930, when only one-fourth of all major social science contributions required major amounts of capital. Since 1930 more than three-fifths of all contributions have required relatively large amounts of capital, particularly for survey research and large-scale tabulations (see Table 3), and this proportion seems likely to increase in the future. If explicit quantitative results are desired, the requirement for capital support becomes still stronger. Low-budget research, the work of lone individuals, or work on nonquantitative topics may play a smaller and smaller role. The industrial revolution in the production of knowledge has not only reached a large part of the natural sciences but has reached the social sciences as well.

Where the pioneers were

An analysis of major social science contributions by location is difficult because many investigators moved during the course of their work and because many advances involved the work of several investigators with changing institutional affiliations. Also, our own greater familiarity with some countries, institutions, and fields of social science may have distorted our assignments of location. Nevertheless, some relationships in the data come out so strongly that it seems unlikely that they could have been produced by errors of this kind, and they raise some interesting questions about the conditions for creativity in the social sciences.

The results of the geographical analysis of the data in column 4 of Table 1 are shown in Tables 4 and 5. In this coding we have counted all locations where any of our 62 important advances appear to have been initiated, which gives a total of 101 locations. However, the continuation of an advance initiated elsewhere was not counted separately, even if the initiator had moved to the new location to carry on his work. Thus, the work of the Vienna circle in the philosophy of science was credited both to Vienna and Berlin (H. Reichenbach) but not to Chicago, where the work was continued after 1936.

Tables 4 and 5 show that in the period 1900–29 Europe produced three-fourths of the contributions, but after 1930 the United States produced more than three-fourths, even though our method of coding tended to favour the assignment of contributions to their first origins in Europe. (Of the American contributions in the second period, only five could be credited in the main to European-born Americans).

Two countries, the United States and Britain, produced more than 50 per cent of all major social science contributions in the 1900–29 period, and almost 90 per cent in the 1930–65 period. After 1930, contributions made in the United States greatly exceeded those from the rest of the world.

Within countries, a very few capital cities or university centres accounted for the great majority of all contributions; other cities and university centres of comparable size contributed little or nothing (see Table 5). Of the British contributions, one-half or more came from London and one-third from Cambridge, but the social science contribution of Oxford was minor. In the United States, one-half of all contributions before 1930 came from Chicago (7 out of 12). For 1900–65 as a whole, three centres — Chicago, Cambridge, and New York — provided more than one-half of all American contributions, with Washington, Ann Arbor, and New Haven providing another one-quarter. Since these six centres represent only a small minority of American social scientists (20 per cent in the 1968 edition of *American Men of Science*), they evidently achieved an increase in effectiveness by an order of magnitude for the men working in these centres, with one-fifth of the scientists producing about three times as many contributions as the remaining four-fifths. By contrast,

TABLE 4. GEOGRAPHIC LOCATIONS OF MAJOR SOCIAL SCIENCE ADVANCES, 1900-65 (BY CONTINENTS AND BY COUNTRIES IN EUROPE)

	By continents				*By countries in Europe*							
	Europe	*North America (U.S.A.)*	*Other*	*Total*	*England*	*Germany*	*Russia*	*Austria*	*France*	*Switzerland*	*Other*	*Total*
1900–29	33	12	4	49	13	8	4	3	1	2	2	33
1930–65	11	41	0	52	4	2	1	1	1	0	2	11
1900–65	44	53	4	101	17	10	5	4	2	2	4	44

Table 5. Geographical locations of major social science advances, 1900 to 1965 (by cities)

	1900 *to* 1929	1930 *to* 1965	1900 *to* 1965
England			
London	7	2	9
Cambridge	4	1	5
Oxford	2	0	2
Manchester	0	1	1
Total	13	4	17
Germany			
Berlin	3	1	4
Heidelberg	2	0	2
Frankfurt	1	1	2
Munich	1	0	1
Freiburg	1	0	1
Total	8	2	10
Austria			
Vienna	3	1	4
Russia			
Leningrad	2	1	3
Moscow	1	0	1
Shushenskoe, Siberia	1	0	1
Total	4	1	5
Others in Europe			
Paris	1	1	2
Turin	1	0	1
Lausanne	1	0	1
Herisau	1	0	1
Brno	1	0	1
Rotterdam	0	1	1
Stockholm	0	1	1
Total	5	3	8
United States			
Chicago	7	3	10
Cambridge	1	9	10
New York	2	5	7
Washington	0	5	5
Ann Arbor	1	3	4
New Haven	1	3	4
Ithaca..	0	2	2
Pittsburgh	0	2	2
Philadelphia	0	2	2
Princeton	0	1	1
Orange	0	1	1
Baltimore	0	1	1
Madison	0	1	1
Bloomington	0	1	1
Berkeley	0	1	1
Santa Monica ..	0	1	1
Total	12	41	53

centres like Berkeley and Princeton, so eminent in other scientific fields, each initiated only one major social science contribution during these 65 years, and a metropolis like Los Angeles made no contribution at all.

These concentrations of social science achievements in particular countries and particular centres seem to be even more marked than the concentrations in modern physics and biology, and they do not seem directly related to any general factors such as increased war funding or science funding in the fields involved. We surmise that contributions to social science may be extremely sensitive to external economies, such as the presence of local subcultures with other first-rate investigators and facilities in other fields, as well as to an intellectual climate specifically favourable to social science in the country and in the local community.

More than three-quarters of all contributions were made under democratic regimes. The remnant were made under authoritarian regimes and under communist dictatorships. Anticommunist totalitarian dictatorships such as Italian Fascism, German National Socialism, and Japanese militarism produced no major social science contributions at all.

In institutional terms, universities have been the prime source of intellectual advances (Table 1, column 5), but in the later period it is the university and government interdisciplinary institutes and " think tanks " that have accounted for about two-thirds of all contributions, as shown in Table 6.

Disciplinary or interdisciplinary?

Interdisciplinary work has been a major intellectual source of contributions throughout the period; responsible for nearly one-half of all advances from 1900 to 1929, it produced nearly two-thirds of the total thereafter. This growing importance of interdisciplinary work reinforces our finding of the great importance of locating social science work at major intellectual centres, in proximity to many kinds of information and expertise from many disciplines. Locating a highly specialised social science enterprise at a small town or college, " far away from all distractions," seems, on the contrary, to be a very promising prescription for sterility.

Relation to social practice, demands, and conflicts

Details will be omitted here, but our analysis indicates that practical demands or conflicts stimulated about three-fourths of all contributions between 1900 and 1965. In fact, as the years went on, their share rose from two-thirds before 1930 to more than four-fifths thereafter. The contributions of

TABLE 6. TYPES OF INSTITUTIONS WHERE MAJOR SOCIAL SCIENCE ADVANCES WERE INITIATED, 1900 TO 1965

Type	1900 *to* 1929	1930 *to* 1965	1900 *to* 1965
1. University chair of lectureship ..	19	10	29
2. Institute or project	6	12	18
3. Government research organisation ..	2	7	9
4. Combined items 2 and 3	8	19	27
5. Nongovernmental political organisation	5	0	5
6. Other	1	0	1
Total	33	29	62

" ivory-tower " social scientists in the future seem apt to be minor indeed.

Major social science advances were applied to social practice in almost exactly the same proportion as they were stimulated by it, and they showed considerable practical importance. Applications were most frequent at the level of social groups. Applications to problems of individuals occurred in about one-quarter of the cases in both periods. Applications to national policy increased from about one-third before 1930 to about two-thirds thereafter.

Increasingly, however, the same social science contributions produced applications at more than one level of the social system. Applications to individuals and groups, to groups and states, or to all three levels together rose from less than one-half of all advances before 1930 to more than two-thirds of all advances between 1930 and 1965.

On the record, major advances in social science have been highly usable in practice and increasingly more so in the recent past. In all likelihood, such advances will be still more usable in the years ahead, if we take the trouble to make them so.

Time delay in the impact of major social science advances

Like all advances in any science, social science advances take time before they have any identifiable impact on a broader field of scientific activity or on the practical affairs of society. Our estimates of this delay for each of the advances on our list are given in the last column of Table 1.

For the period 1900–65 as a whole, the minimum delay of the impact for nearly three-quarters of the major advances was less than 10 years, the median delay was about 10 years, and the maximum delay was in the neighbourhood of 15 years. These figures may understate the true length of the delay because for the recent period, as for any time-limited study, the achievements with longer delays are less likely to be recognised and are under represented. As a practical rule of thumb it may be safer, therefore, to expect the first major impact of a social science advance to be delayed by 10 to 15 years after its inception.

Nevertheless, the delays in the recent period seem to have been decreasing as might be expected in a society with greatly increased higher education and faster communications networks. The most frequent median delay time dropped from between 11 and 20 years in the years 1900–29 to less than 10 years in the years 1930–65; and the most frequent maximum delay time declined from about 25 years before 1930 to about 15 years in the more recent period. If one wishes to extrapolate from these data, one might surmise that the time lags of impact may be further shortened in the future. However, part of this decrease in the time delay may be due to the tendency of research institutions or governments today to support research that is expected to have an early impact on practical affairs, and it may not be characteristic of more fundamental contributions.

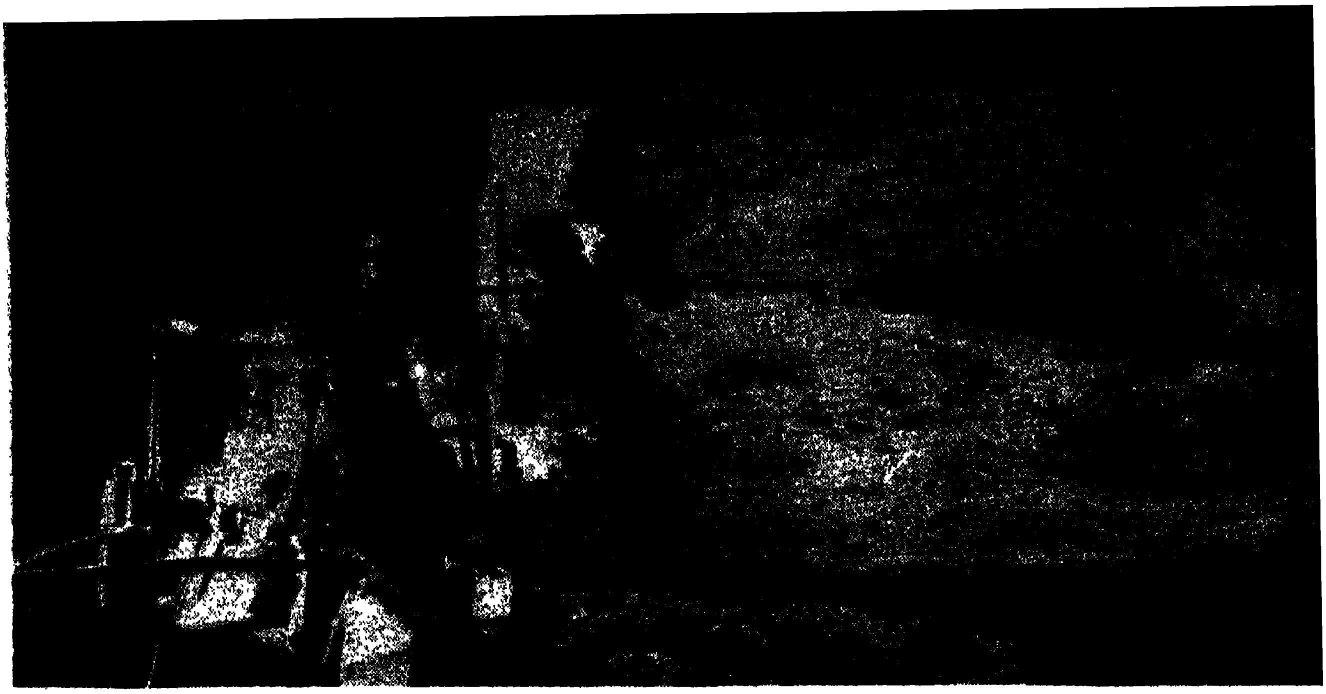
These time data suggest the desirability of extending the support of fundamental social science research efforts in the form of 10- or 15-year programmes at clearly favourable locations. This more sustained support might encounter political and bureaucratic difficulties, but it would seem to be the most promising strategy for making and consolidating advances like those described here in our basic understanding of social relationships and in our ability to solve pressing social problems.

The radical increase in natural science knowledge and in its application has produced a radical increase in the problems of coordination in all industrialized societies. To cope with this radical increase in urgent problems it seems essential to produce an early and large increase in social science knowledge and its constructive applications. The evidence here suggests that the intellectual and organisational means for such an increase are at hand if we care to use them.

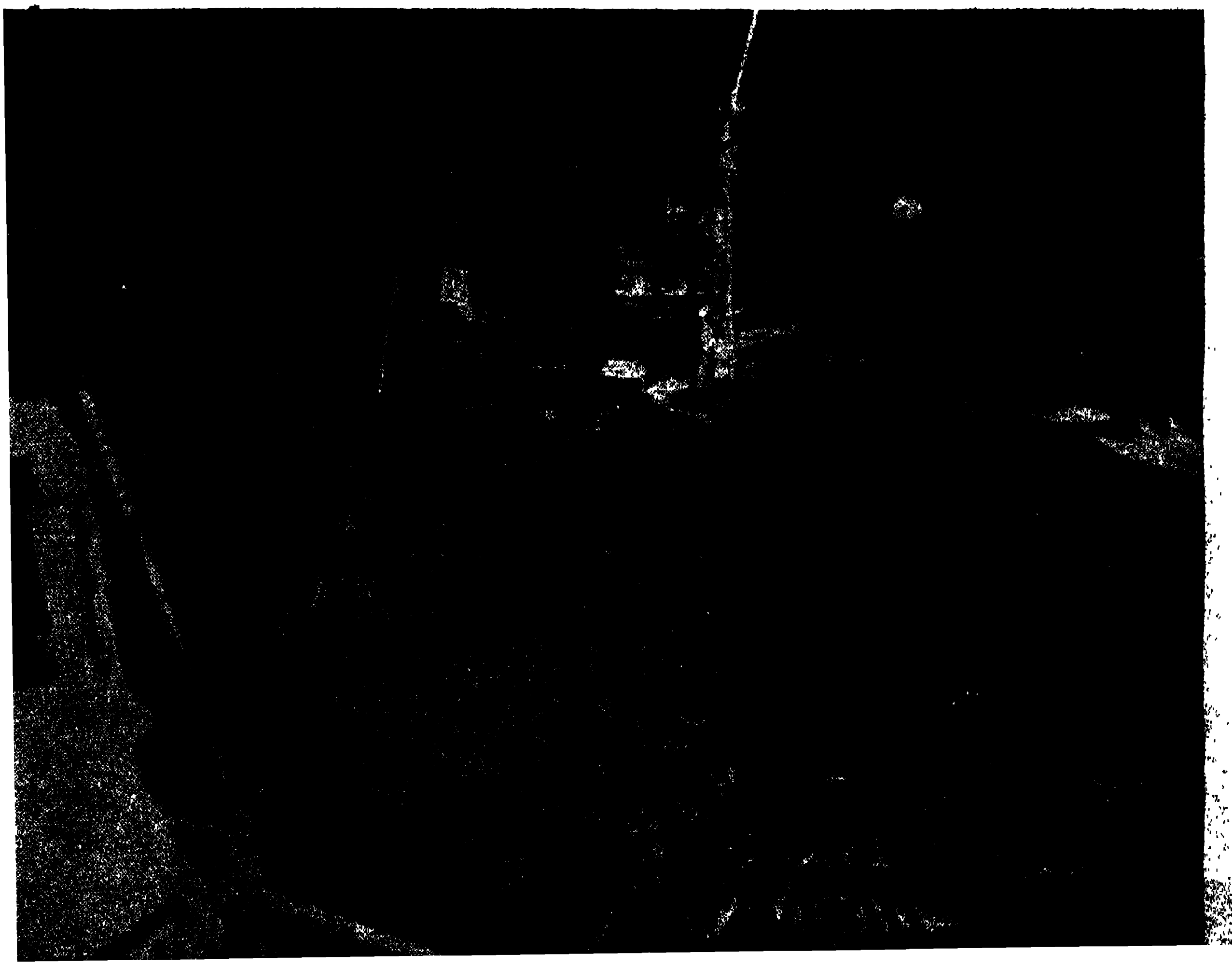
Edgar Mitchell with the Modularised Equipment Transporter (MET), or tool cart, during the second walk in the Moon's Fra Mauro highlands on 6 February 1971. Crossmarks are part of the camera's optical system to help indicate distance

APOLLO 14—The Long Walk

The extravehicular activity (EVA) checklist is visible on Alan Shepard's wrist in this view taken by a 16 mm sequence camera mounted on the hand-pulled tool cart. In the distance, Edgar Mitchell deploys scientific devices. The picture was made during the first walk on 5 February

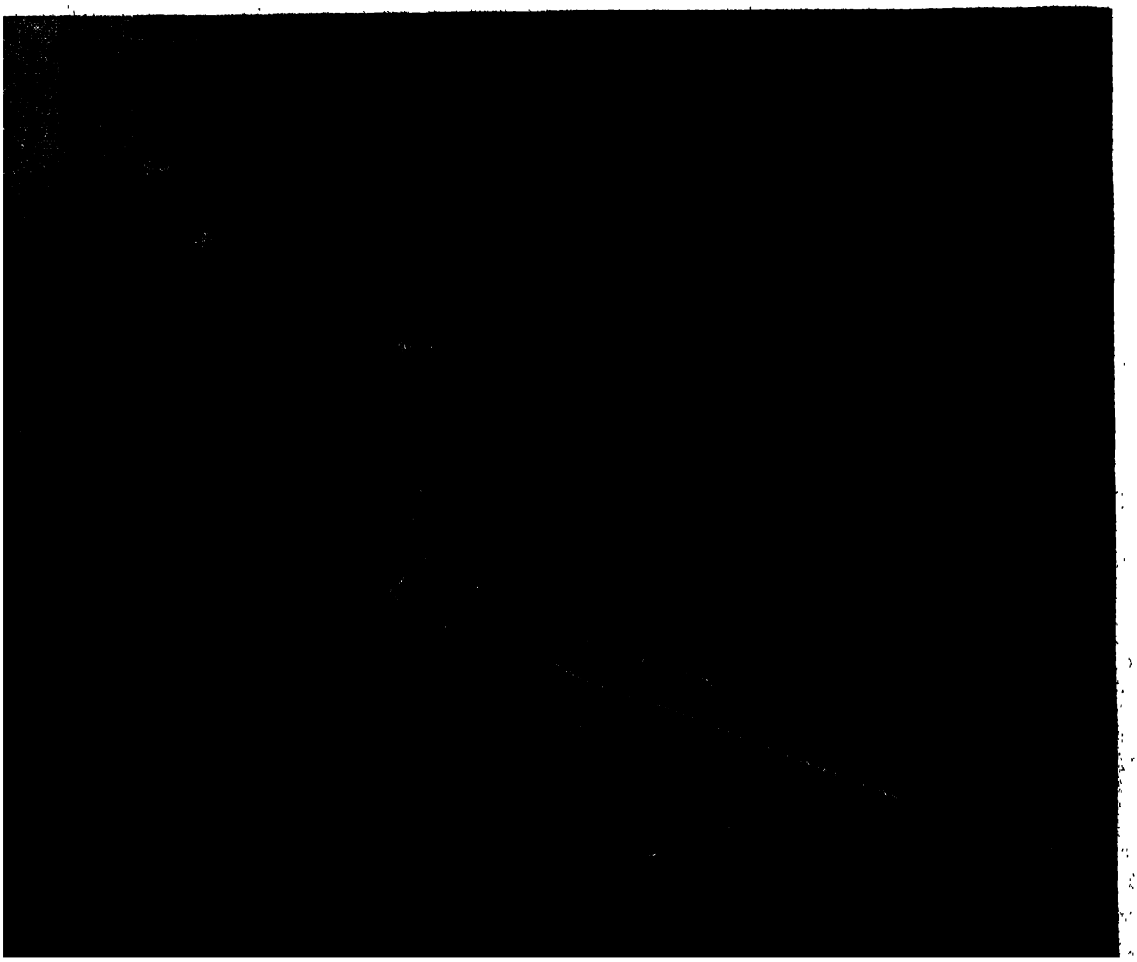


Above: Alan B. Shepard, Apollo 14 commander, stands near MET on lunar surface while he assembles hand tools during first EVA. MET was used by astronauts to transport tools for geologic samplings, experiments and equipment. Below: The central station of the Apollo lunar surface experiments package (ALSEP) handles power and data distribution. In the background are several of the scientific devices set up near the Apollo 14 landing craft during the first walk in the Moon's Fra Mauro highlands. Part of the hand-pulled equipment transporter is visible in left foreground



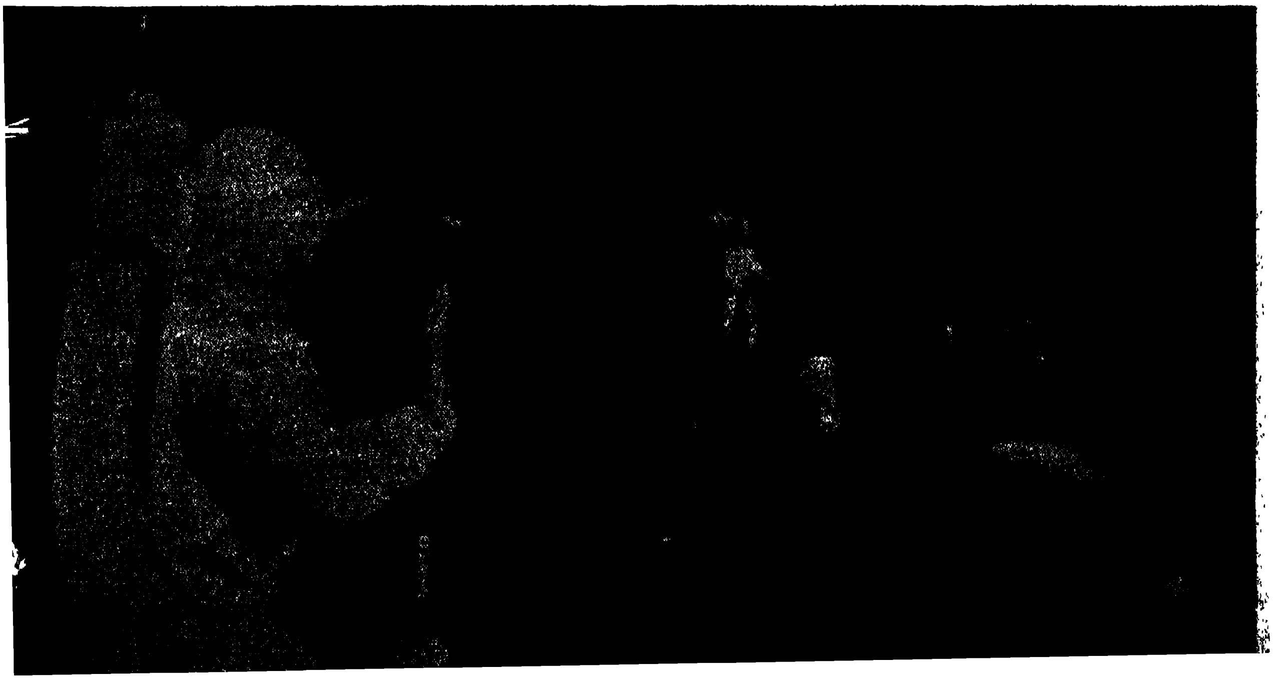
Commander Shepard standing near large boulder. The Apollo 14 crew brought back nearly 45 kg of lunar material to Earth

Below: Wheel tracks left by the hand-pulled tool cart lead away from the Apollo 14 landing vehicle Antares in this view taken during the spacemen's second walk on the lunar surface. At left is the inverted umbrella of the S-band communications antenna



Above: Shepard's shadow is visible as he [illegible] in extensi [illegible] ld just northwest of Antares landing site. Note hammer lying on one of the boulders

Below: Astronaut Edgar Mitchell (left) carries the thumper device used to set off shock waves to provide scientists on Earth with data on the Moon's crust. In the distance, Alan Shepard walks near the deployed components of the ALSEP. Picture was taken by an automatic 16mm camera mounted on the tool cart



VULTURES

THE carcass lies in the middle of a stubbly field under the blazing sky. It may be a cow, a buffalo or game from a nearby forest. The species does not matter. It is dead and it is waiting. For the vultures.

Far above in the blue sky a tiny speck of black seems to grow larger and larger as it comes spiralling down and brakes to a halt a few feet from the carcass. Then another speck in the air has seen it. Then others. And still others. The field is soon buzzing with the muted restlessness of these huge ghoulish and sombre birds.

Having arrived they wait for the party to begin. Who will cut the cake (sorry carcass)? The beast has not been dead long and its hide is too tough for the vultures' beak. All they can do is wait for rotting to begin or for some strong-billed vulture (or any other bird) or mammal to begin the dissection for them. Naturally, the weak-billed ones must wait till the others have stuffed themselves. Sometimes they get impatient and barge in to try their luck but are driven back. While the fight is on, someone else, maybe a weaker species, snatches mouthfuls. This sort of intraspecies bickering is rare as there is an established peck order among them, depending solely on the size of the beak. Holding the prey down with their strong feet they pull and tug at the flesh, swallowing it whole, all the time quarrelling with the weaker and more timid birds of their own species. Sometimes while vultures of a lower peck order are feasting, those of a higher order may arrive; then the first-comers must make way for the new arrivals.

They proceed with their noisy meal in a systematic way. The bald head, featherless long neck and legs — all help in probing the insides of the carrion. As they keep stuffing themselves, the featherless crop, hidden so far under the breast feathers, begins to protrude.

Vultures are gluttons and having eaten all they can, they must stay on the ground. Or else, to fly away, they need sufficiently long runways (about 12 to 16 metres). A few species like the white-back Bengal vulture (*Pseudogyps bengalensis*) are forced to spend the night on the ground. If surprised or attacked in this condition, the grounded bird can disgorge and take off. Alas for the hearty meal but life is more precious!

After a meal they wash in water and dry themselves by spreading out their wings in the sun. Then they settle down for a nap while waiting for the food to get digested. Like all predatory birds they disgorge pellets of undigestable matter. Once the vulture feels light enough to take off, it soars into the sky again, keeping an eye on the happenings on the ground and on its immediate neighbours.

The vulture's sight is said to excel that of all other birds. The distance between the lens and retina in its eye is great enabling it to see two closely situated points distinctly even from distances of hundreds of metres. A serious handicap arising from this arrangement is its small field of vision. The pecten, a serrated comb-like organ which is supposed to detect movement and convey it to the brain by casting a shadow on the retina, is well developed in the vulture's eyes.

Whether smell plays an important part in the vulture's hunt has long been a question of dispute. Many insist that they can find hidden prey which means their olfactory sense must be quite acute. Some maintain that they have learnt to associate worms and larvae as signs of a decaying body. Some claim that they can distinguish the smell of a decaying carcass but not of fish. When John James Audubon covered a carcass with a canvass, he found no vulture came near it. He also discovered that these birds, on the other hand, were attracted by a painting of dissected sheep. It has been established that vultures of wooded areas have a better sense of smell than those of the desert areas. It is agreed that they do have a better sense of smell than most birds, but this is nothing remarkable by itself.

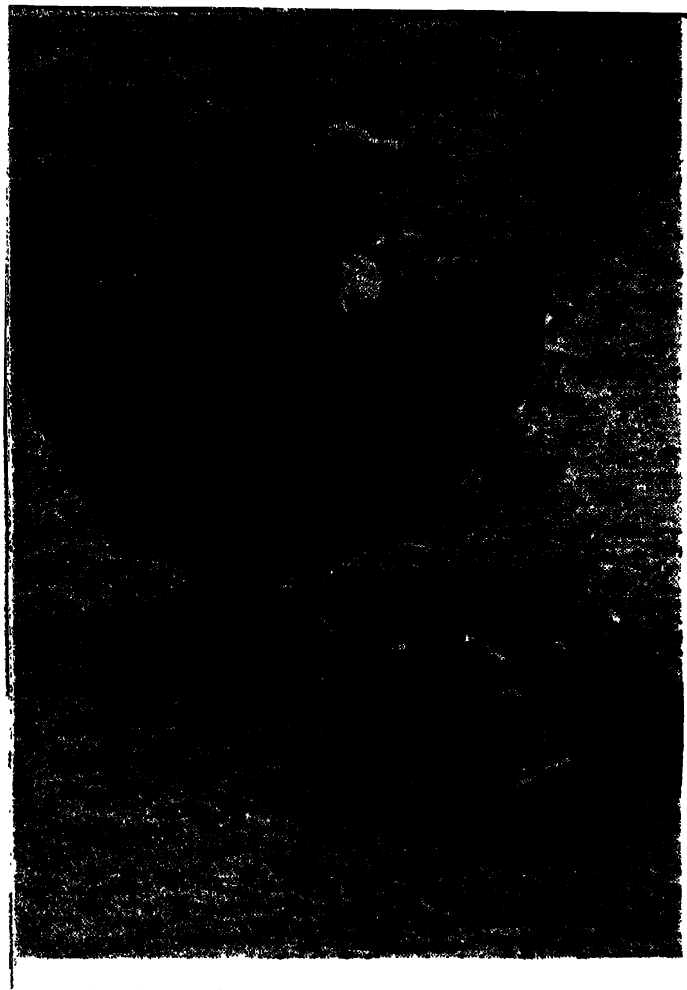
At close quarters few would describe a vulture as handsome. In fact it is ugly, grotesque and even smelly. But when airborne, the same monster is a picture of grace. Being a huge bird, the vulture has to run and pick up speed to take off — especially after a meal. The ratio of wing area per unit body weight is very high. Though this is a disadvantage in swift-moving air currents, once the bird has gained height, this acts as a superb balancing organ. To soar into the sky the vulture makes use of rising hot air currents to lift it on its huge outspread wings. In the air, its flight is maintained by these thermal currents, the downward pull on bodyweight overcome by the upward-moving air currents. In short it is like going down an up staircase. It does not even have to flap its wings perceptibly once airborne.

Being carrion-feeding birds, their food supply depends mainly on accidental finds and not on their skill as predators; hence they do not have well-developed territorial instincts. Some of them are social birds living in communal roosts once breeding duties are finished, while others live as solitary pairs.

Nests are usually built with sticks on ledges of cliffs but some are ground-nesters. They lay few eggs — 1 or 2 and rarely 3. Some breed only once in two years. The eggs incubated by both parents hatch after a long time. Compared to birds of similar size, the vulture's young mature and develop fledge (feathers and wings) very slowly. The downy feathers of the newborn are replaced later by adult plumage. All the time they are in nest they are fed by the parents who give them half-digested food from the crop. It is many weeks after they are hatched that the young leave the nest. Yet they are not very intelligent birds, and it's years before they start breeding. To compensate for the slow growth and multiplication, they have an unusually long life (about 50 years).

Unlike the other birds of prey, vultures rarely kill for their meals, although there are tales of their scaring animals from clifftops who hurtle down to their death below. They will try to attack and kill only if the victim is too weak to fight back. They lack the clasping talons of the other raptores and their legs are more adapted to walking and holding down the prey while tearing it with their beaks. They have a fascinating natural protective device. As most of them are scavengers gorging themselves on decomposing flesh — which could also be the remains of a diseased animal — their head, neck, legs and any other portion which are likely to come into contact with putrid flesh remain bare and dry, exposed to the ultraviolet rays of the Sun which kill any harmful bacteria. If these body areas were feathered, they

Facing page: This white-backed vulture has temporarily driven others off (a feather from a competitor in its beak). Below: White-faced vulture. When fully adult, it loses the dark fuzz on the crown



Black (lappet-faced) vulture, also known as king vulture

would get matted with blood and body fluid, facilitating microbial life.

Not only the exterior, but also the alimentary canal is fortified against infection. Strong digestive juices annihilate any disease-carrying germ. It is also believed that their faeces have strong antibacterial qualities; the birds deliberately let these fall on their legs instead of dropping them away from their bodies as the other birds do.

Of all the birds in the air, vultures are the largest. Some of the present-day species have a wing-span more than 3 metres. Among their ancestors were larger birds.

The old world vultures differ vastly from their American counterparts in spite of similar external adaptations. The latter are closely related to the wading and swimming birds and have rudimentary webs on the feet. They differ from their oriental cousins in their longitudinal nostril opening and completely perforated nasal septum. They also lack the voice box — the syrinx. Weak hissing sounds are all they can utter.

Belonging to the family *Cathartidae* of the order Falconiformes — which also include the old world vultures — are two of the largest flying birds: the Adean condor or *Vultur gryphus* (wing-span 3·05 metres) — and Californian condor *Gymnogyps californianus* (wing-span 2·9 metres). Also two of the largest flying birds that ever existed are grouped under this family: *Terratornis incredibilis* (wing-span 4·9 to 5·2 m), and *Terratornix meriami* (wing-span 3·4 to 3·7 metres). At present there are six living species in America backed by several extinct ones.

The old world vultures — family *Accipitridae*, subfamily Aegypiinae — which evolved 30 million years later are not so dumb. They are closely related to the eagles. The lammergeier — *Gypaetus barbatus* — is a link between the two. Also known as the bearded vulture, this fierce bird resembles the eagle in feathered face, legs and prehensile claws. It has a wing span of 2·4 to 2·7 metres.

There are three species of vultures in India. The black vulture (known locally as Pondicherry vulture or king vulture) — *Sarcogyps calvus* — is the only Indian species with a beak strong enough to tear fresh flesh. The white-backed Bengal vulture — *Pseudogyps bengalensis* — is widespread throughout the country. A gluttonous bird, it is often obliged to spend the night on the ground due to overeating. It is also a pugnacious bird. The third species, commonly called the Pharaoh's chicken — *Neophron percnopterus* — is a small bird thriving on garbage.

Few of the other old world vultures include *Aegypius monaclus* — king vulture with a 2·7-metre wing-span. *Torgos tracheliotes* — the lappet-faced vulture, which has a powerful beak and can tear through the hide of elephants, hippos and rhinos, is an aggressive bird. It is the first to gorge itself while the others wait their chance. The Griffon vultures or *Gyps indicus* are sociable birds with very long, craning necks.

The huge size of vultures is no insurance against death. Where they cannot be killed by guns they are brought down by poisoned bait. The lack of large carcasses, which man now disposes of differently, has been forcing a few species to become birds of the past. In fact, the California condor is winging its way to extinction though it is now protected by law. And then not all vultures are huge and gigantic. Some of them even fall prey to other predatory birds.

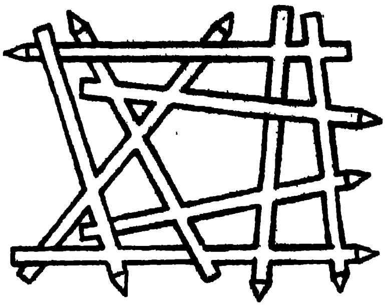
Ugly, and maybe even ghastly, the vulture has been considered an ill omen in India. Yet, in spite of the hatred and disgust it evokes, it is a useful bird clearing up refuse efficiently, and it can even boast of having been worshipped in ancient Egypt as the bird sacred to Nokhebt — the goddess of fertility.

Sumati K. Sampemane

BRAIN TEASERS

Puzzling pencils

There are nine pencils here altogether. Two are resting on the table and are supporting two more which, in turn, are supporting another pair, with a fourth pair on them and a single pencil resting on the top pair.

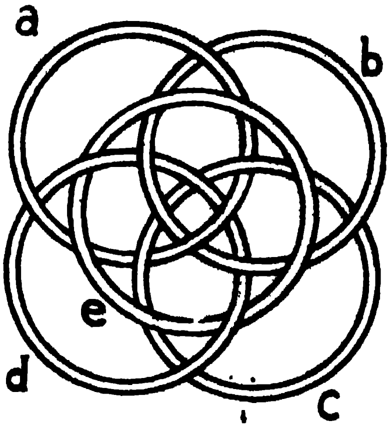


Unfortunatey the artist hasn't finished the drawing, and most of the crosslines showing which pencils are resting on which are missing.

Can you complete the drawing and thus discover which is the top pencil?

The five tangled-up rings

The five lettered rings in the drawing are linked together in a complex tangle.

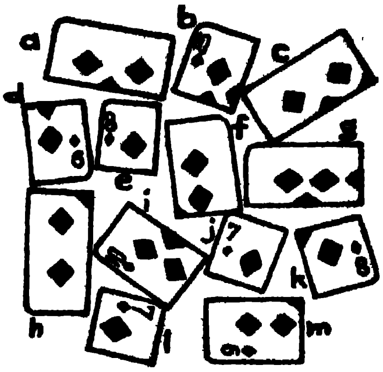


As they stand, none of the rings can be detached from the bunch. What is the smallest number of rings which must be cut in order to free all five rings from one another?

Destructive card game

It wasn't quite what Aruna had meant when she agreed to young Arjun borrowing the scissors to "cut pretty patterns."

Coloured paper is what she had been thinking of, but Arjun set to work on the family pack of playing cards!



Not only had several cards been sliced into pieces, but some of the pieces were actually missing. From those shown here, how many complete cards can you assemble?

Don't cut the diagram from the page. Try to assemble the pieces in your head — it's a far more challenging problem that way.

Xeno

(Solutions next month)

Solutions to last month's Brain Teasers

Hotplate poser: Fifteen moves are necessary: a — 2, b — 1, a into b, c — 2, a into d, b into c, a into b, d — 1, a into d, b — 3, a into b, c into d, a — 2, b into c and a into b.

The murmurers: Mrs. Banerjee is secretary, Mrs. Thomas outings organiser, Mrs. Gupta treasurer and Mrs. Singh president.

If you have arrived at some other answer check to see where you have made some subtle mistake.

For instance, you can't have Mrs. Thomas as treasurer with Mrs. Gupta as outings organiser because then the treasurer would be the outings organiser's aunt. Since Mrs. Thomas is the secretary's sister, she must be the aunt of Mrs. Gupta, who is the secretary's daughter.

Alive and kicking in a match box: Well, did you get it right like this:

```
  62257
 ×  683
-------
 186771
498056•
373542••
--------
42521531
```

A GENTLE REMINDER:

TWA IS THE WORLD'S LARGEST AIRLINE SERVING INDIA.

Offices in Bombay • Calcutta • Delhi • Madras • Ahmedabad

Based on revenue passenger miles in the free world.

[illegible]

Global Geophysics. Ed. Sir Graham Sutton, **English University Press Ltd.**, London, 1970, 4 chapter, 260 pp, 45S.

THE primary task of any book on science is to inform. If the book happens to be written by one or several experts, it carries its own stamp of authenticity. It also carries the risk of being a "difficult" book, because not all experts are able elucidators. In this respect, *Global Geophysics* is a book of mixed qualities : while two of its contributors lean heavily on the academic side, the other two fare rather well in writing for the lay reader.

Global Geophysics has four main chapters, each written by an expert in the field, dealing with four important branches of geophysics : Earth in space, geodesy, seismology and geomagnetism. One cannot fail to notice the absence of certain other topics in which there has been considerable progress in recent times, viz aeronomy, atmospherics, field geophysics and instrumentations. These are pardonable omissions as the emphasis is on giving a background of the fundamentals and on indicating the current research activities in each branch and thereby initiate the interested into further delving in geophysics.

The first chapter, written by R. H. Tucker, deals with Earth in space and its various motions. The author has very lucidly explained the spatial and size relationship of the Earth with respect to the other planets in the solar system. However, a table giving the details on orbital diameter, mass diameter of the planet, etc normalised to the Earth might have proved more illustrative than the method used by the author. He asks the reader to visualise the Earth as a ball, with a diameter of an inch, 237 yards from the Sun ; with this parameter, the other planets are to be viewed in corresponding sizes and distances. Though this approach has a novelty value, it does not bring out the salient differences clearly. However, the explanations of the various motions of the Earth will prove useful in enabling the reader understand the complicated wobbles clearly.

The next chapter, on geodesy, is written by A. H. Cook. The study of geodesy requires an understanding of gravitation. That is, to understand the external shape of the Earth, one has to know the gravitational forces acting at different regions on the Earth. The chapter starts simply enough with a straightforward introduction. But then it meanders through rather difficult equations of gravitational forces involving vector calculus. The subsequent treatment of the subject is as complicated, so much so that it proves hard to appreciate the survey methods discussed in the last part of this chapter.

A piece on seismology, written by H. M. Iyer, forms the third chapter. Iyer gives the reader a clear insight into the physical phenomena involved in Earth tremors. The enormity of these forces that act from within the Earth and cause earthquakes and volcanic eruptions is both fascinating and terrifying. The author moves gradually from an explanation of the various waves generated from the epicentre of a quake and their characteristics to a description of the different kinds of seismometers. He also discusses the structure of the Earth as derived from seismological observations and the causes and distribution of earthquakes. To illustrate he gives details of the causes attributed to earthquakes and describes the major earthquakes. The chapter also helpfully explains the intensity of earthquakes given as magnitudes in different scales. Iyer sums up with a discussion on geophysical problems like ocean-floor spreading, along with modern methods of oil exploration and detection of underground nuclear explosions. This chapter is very comprehensive and gives a good introduction to seismology as it brings out all the new ideas prevalent in the field.

The last chapter, on geomagnetism, written by F. D. Stacey, is in four parts : Earth's main field, paleomagnetism, magnetosphere (and radiation belt) and magnetic storms (and associated effects).

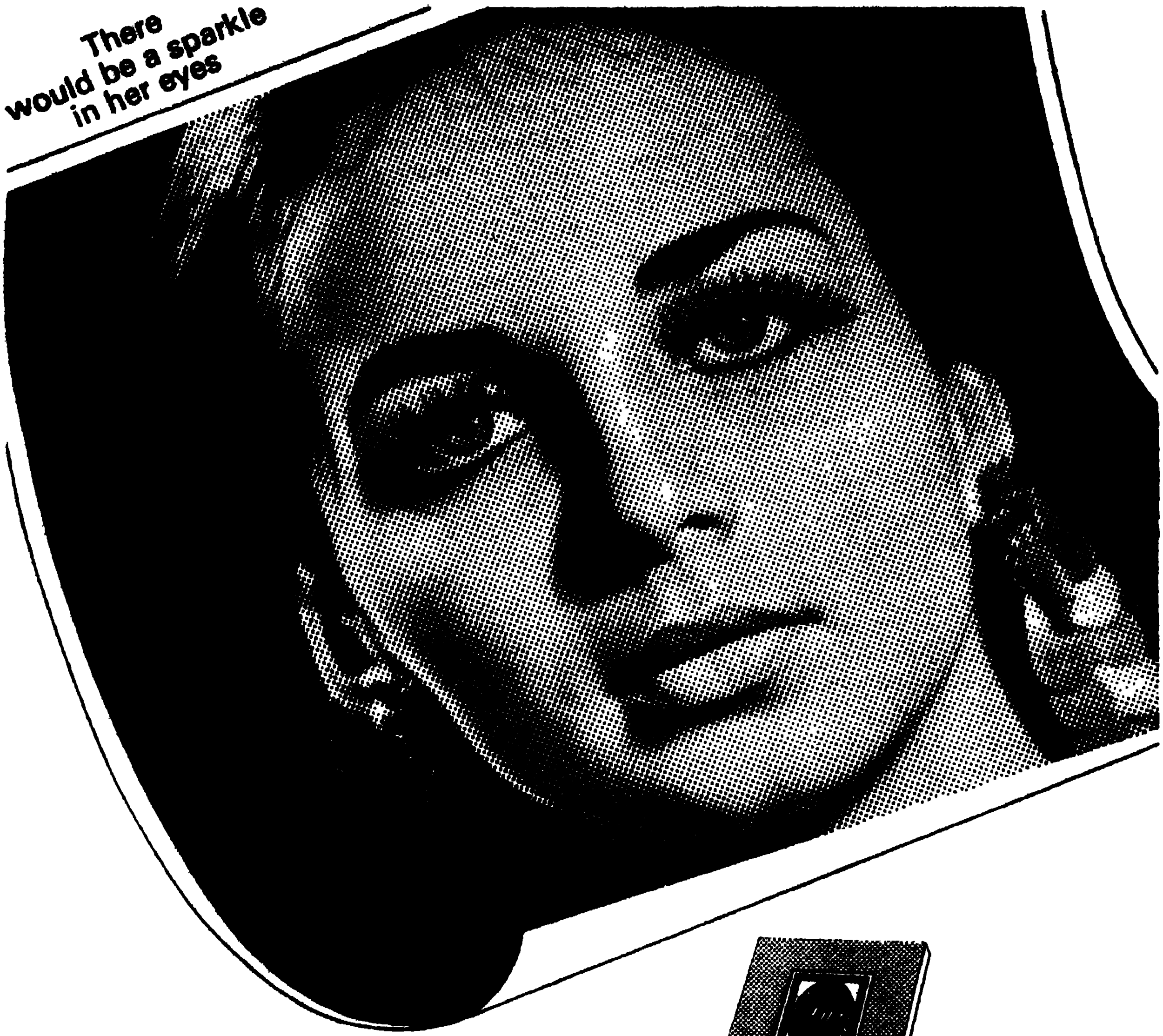
The first part which deals with the dynamo theory for the presence of the main dipole field and secular variation of the non-dipole field is well explained and the current ideas are clearly stated. Paleomagnetism of rocks, magnetic polarity reversals and the evidence of ocean-floor spreading and continental drift from a study of magnetic reversals of the ocean bed are discussed in the second part. One would have liked some more discussions on magnetic reversal studies based on the ocean sediment cores and details regarding different epochs and events of magnetic reversal.

The third and fourth parts describe the interaction of solar plasma, solar flare particles and cosmic rays with the geomagnetic field at the magnetospheric boundary and related effects. These current ideas are well brought out and the reader will get a clear picture of the physical phenomena connected with the geomagnetic field that take place at the outer fringes of our atmosphere.

May prove to be a worthwhile book if it inspires some further reading.

G. Rajagopalan

[Dr. Rajagopalan is with the Geophysics Group at TIFR, Bombay.]

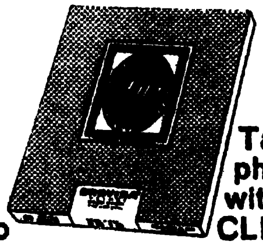

There would be a sparkle in her eyes

...if only this were printed on Agfa-Gevaert Photo Paper.

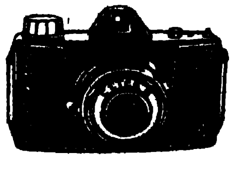
® Registered Trademark of Agfa-Gevaert, Antwerp/Leverkusen. Manufacturers of Photographic Products.

That's right! Ask for the best. Specify Agfa-Gevaert Photo Papers. That way you'll never miss out on quality and tonal excellence.

For flawless results, it's Agfa LUPEX for contact prints. Agfa BROVIRA for enlargements.



Take up photography with AGFA CLICK III best to start with, best to stay with!



Available at all authorised Agfa-Gevaert dealers.
Made in collaboration with Agfa-Gevaert A.G., Leverkusen, by:
The New India Industries Ltd., Baroda & Bombay.

Sole Distributors:
AGFA-GEVAERT INDIA LIMITED
Bombay • New Delhi • Calcutta • Madras

CMAG-142-283

FOR YOUNG READERS

SOUND FILM

'Talkies' are so much a part of our life that we take them for granted. Yet at one time films were silent. The breakthrough came when it was found that sound tracks could be printed on the film itself. How is this done ?

WHEN films were first made, they did not have any sound. Trains rumbled silently across the screen, guns fired with a puff of smoke but no bang and actors did not talk. Inventors had tried right from the very beginning to introduce sound into these silent pictures. Their first successful attempt was to play a wax disc along with the moving silent film. The disc carried the sound record of the film. But synchronisation was difficult in this case. Finally a method was discovered in which the sound track was printed on the film itself. This method overcame all the difficulties that had existed till then and is still used to this day.

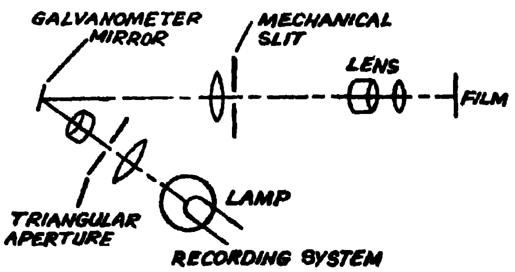
In sound films, synchronisation is very important, ie the sound and the moving film should be tied together accurately. When an actor speaks in the film, his words should be on the sound track at that exact moment. To ensure this, the sound and film are recorded at the same time on the same film in the studio or on location.

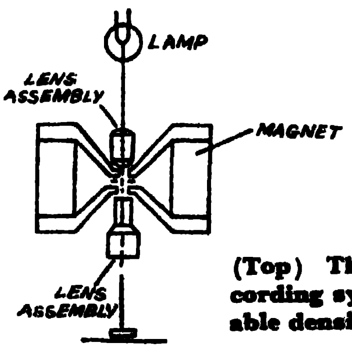
Films are, of course, photographed with cine cameras. But sound cannot be photographed. To add sound on the same film on which the picture is photographed, the sound is, therefore, converted into light.

When an actor speaks into a microphone, the sound of his voice is converted into electric currents, ie the pitch and volume of his voice are converted into electric currents. The pitch becomes the rate or frequency of the current and the volume becomes the size of the current. When there is more than one microphone, as when two or more actors speak, the currents from each microphone are fed into a mixer which balances them. These varying currents are amplified in size and fed to a galvanometer. The galvanometer has a coil of wire for its armature. A mirror is cemented to this coil and it is suspended in a strong magnetic field. When the varying current passes through the coil, the coil, with the mirror, vibrates or oscillates in sympathy with the current. Large currents produce oscillations of large amplitude while high pitched sounds produce a high frequency rate of oscillation.

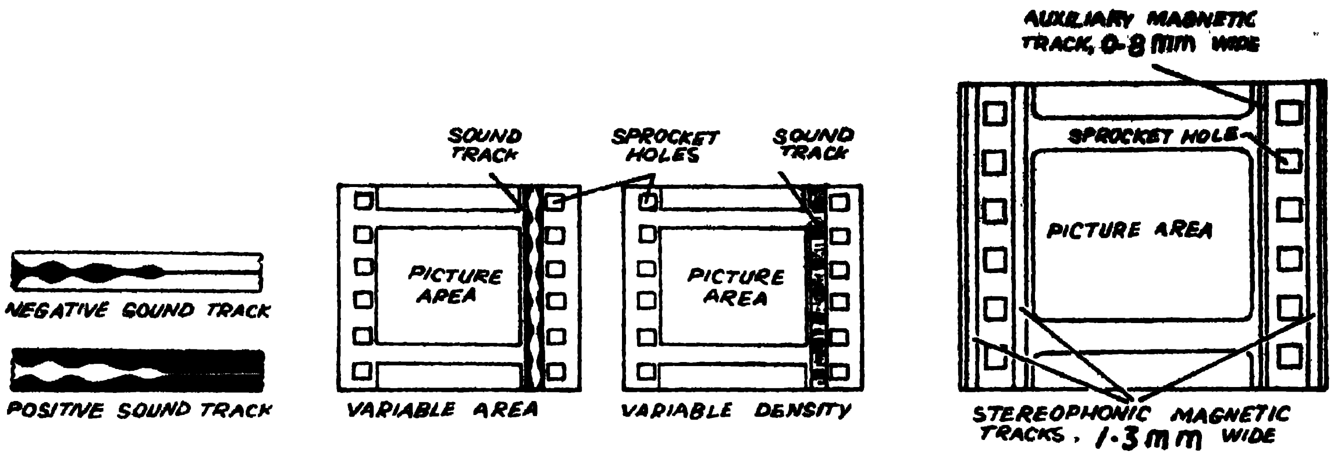
A light from a lamp is now focused by a condenser lens and masked as a triangular beam. This triangular beam of light is directed on the mirror cemented on the coil. The mirror reflects the light which again passes through a lens and focuses on a thin plate in front of the moving film. The plate has a small slit. As the mirror vibrates, the light too moves up and down. The slit thus allows more or less light to fall on the sound track of the moving film. Loud sounds will cause only the top portion of the triangular beam to fall on the film while soft sounds will cause the bottom portion of the triangular beam to be recorded. This means the area of light varies according to pitch and volume of sound. This type of recording is, therefore, called variable area recording.

In another method, variable density recording, a loop of duralumin tape is suspended in a magnetic field. The ends of the loop form a slit. When current passes through the loop, the magnetic field is energised and the loop opens and closes with the variations in the current. This loop is now placed between a





(Top) The variable area recording system. (Left) The variable density recording system



The various types of sound tracks and their position on the film

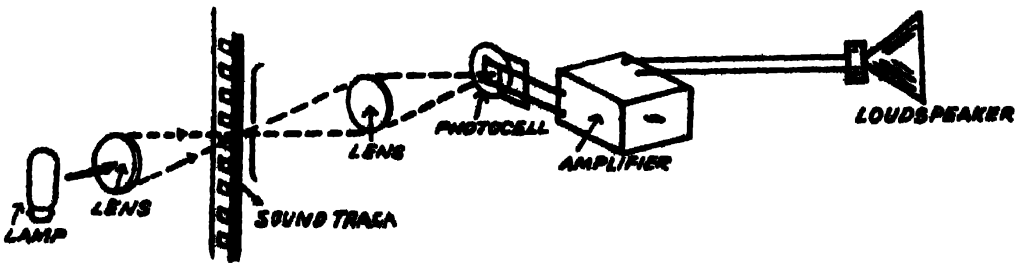
constant light source (a lamp) and the moving film. When the loop closes, less light reaches the film, when it opens more light reaches the film. Thus the density of light recorded on the film is varied.

Sometimes, many cameras may be used to photograph a single scene from different angles. As both the sound and picture are recorded together, there may not be proper synchronisation. Synchronisation is achieved by having an interlocking system between the camera and the sound recorder. The sound and the picture are not recorded side by side on the film because the picture illumination is 'shuttered' while the sound track passes smoothly across the projector. Therefore, the sound is recorded at a distance of about 25 frames after the corresponding picture. After the recording is completed, the film is processed in the usual way. It is then used as the master print from which the circulation positives are made.

In the theatre, the recording process is reversed. That is, the light exposures on the positive film print are converted to sound effects. This is done by focusing a beam of light on the sound track at the point that corresponds to the picture sequence being projected. A photoelectric cell, placed on the other side of the sound track, picks up the light which passes through the sound track and converts it into an electric current. This electric current has the same variations as the light from the sound track has. The current is fed to an audio amplifier which then feeds the current to the loudspeaker system from which the sound emanates.

This entire sound system is a monophonic system. Nowadays with the wide screens (70 mm, etc) the monophonic system proves inadequate. The screen is so large, the actors are separated by large distances. Therefore, the stereophonic sound system with its many channels is used. The sound track in this system is recorded on magnetic tape strips that are cemented to the positive film. If there are three channels, there will be four sound tracks on the positive film, one each for the three channels and the fourth as an auxiliary or control track. In the reproducing system, the information from each magnetic strip channel is fed to voltage amplifiers and then passed to the loudspeakers behind the screen. This system permits better, fuller and more flexible sound effects.

Sound reproduction system



HOW DOES IT WORK?

Electronic Flashgun

LIGHT is of essence to the photographer for it means the difference between a good exposure and a bad exposure. Dark halls and dark nights would prove a bane to any photographer were it not for the flashgun. This important accessory is essential for every photographer's dream of a good exposure in a dimly lit place.

Flashguns come in two types: the ordinary bulb flashgun and the electronic flashgun. The former has a relatively simple construction and is consequently much cheaper — about Rs. 20 each. The disadvantage lies in that each bulb lasts for just a single exposure and as each bulb costs about Rs. 3, the overall expense proves greater in the long run. Moreover the handling is a cumbersome affair. A flashgun of this type is marked *A* in figure 1.

The electronic flashgun is much handier. Amateur and professional photographers prefer going in for one of these. They cost about Rs. 300 each. But then the bulb needn't be changed after every exposure — each bulb has a life of about 10,000 flashes. The light is provided by a gas-filled bulb which gives a bright flash each time its contacts are made. There is no filament in the bulb, just an electric spark — ' miniature lightning ' — which gives enough light for a good exposure. The basic principle of this gun is to charge an electric condenser and discharge it through the bulb in synchronism with the opening of the camera shutter. The condenser can be charged in any of three ways: (1) directly from the mains — through a rectifier of course, for a condenser needs DC current, (2) from dry cells which have to be replaced after 40 to 50 flashes or (3) from chargeable batteries which can be recharged after they are exhausted.

Most flashguns sold commercially nowadays are a combination of either (1) and (2) or (1) and (3).

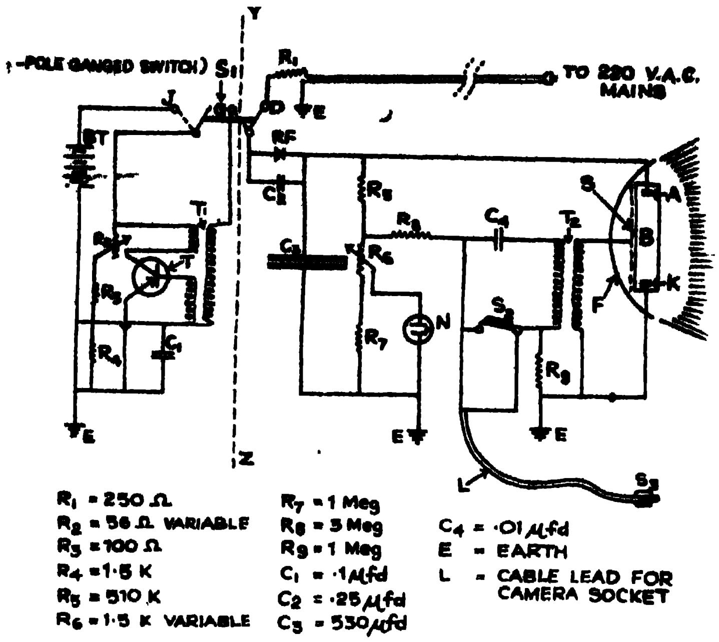
Figure 2 shows a simplified circuit of a commercially well-known flashgun. Its size is a mere 10 × 8 × 3.5 cms and its weight less than 400 gm. To understand its working, first refer only to the portion of the diagram to the right of the vertical line YZ. The mains current (220V-AC) passes through resistance R_1 and rectifier RF and charges the condenser C_3. This is the main condenser which stores the total energy of the flash. It is electrolytic and has a capacity of 530 mfd. Another smaller condenser C (only .01 mfd) is charged simultaneously. When C_3 is fully charged the voltage across its terminals is stabilised at approximately $\sqrt{2} \times 220$ — about 300 volts. At this stage a neon bulb N glows. The value of the variable resistance R_6 is adjusted and fixed so that the neon bulb glows when the full voltage of 300V is attained at the terminals of C_3, indicating full charge. The flashgun can now be fired. B is the gas-filled flash bulb; the two terminals are A (+) and K (—).

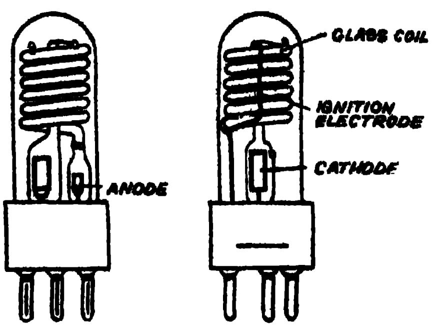
When C_3 is charged, a potential difference of 300 volts exists across the terminals A and K, but the flash does not go off because it is not sufficient to break through the distance of about 3 cm between A and K. The gas in the bulb needs to be ionised. This is achieved by giving an impulse of about 3,000 volts to a metallic screen S, shown as a dotted vertical line, placed along the length of the flash bulb. This screen is connected to the secondary winding of the transformer T_1. When switch S_1 is pressed, it completes the circuit, discharging the condenser C_4 into the primary winding of T_1, thus inducing a high voltage (about 3,000 V) in its secondary. A momentary potential difference of 3,000 volts is formed between the screen S and the terminal K, which ionises the gas inside the bulb. The condenser C_3 instantaneously discharges its total energy across the terminals AK with a blinding flash. F is a reflector that directs the light towards the range of the camera. The flash duration is only about 1/10,000th of a second, but is sufficient for a good exposure.

Electric mains are not always available at the time of photography. An additional self-contained

Fig. 1 Different types of flashguns

In the "You Too Can Do It" column of January 1971, the length of the battery-operated tubelight was erroneously given as 10·6 m. It should be 0·6 m.





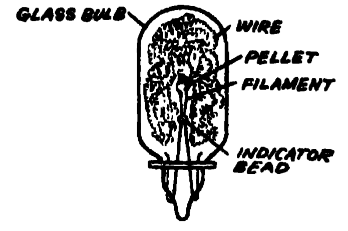


Fig. 2 (Far left) Simplified circuit of the flashgun. (Above) The high voltage flash tube. (Left) The ordinary flash bulb

power-pack arrangement that works on a few dry cells proves a suitable alternative. The circuit of such an arrangement is shown to the left of the line YZ. For operating on dry cells, switch S_1 is pushed to the position shown by its dotted arms. In this position, battery BT (dry cells) connects to the transistor T through the terminal J. The other arm of S_1 leaves the terminal D and connects to G. The transistor oscillates due to the feedback in the primary windings of T_1 (note that the transformer has a three element winding; the primary is in two parts, for obtaining the feedback to make the transistor oscillate). Thus an AC is generated, which is stepped-up by the secondary of T_1, to a voltage equivalent to that of the electric mains. This is passed on through the terminal G to the rectifier RF. Thereafter, the circuit operates in the same way. S_3 is a plug to be pressed into the synchro-contact socket of the camera. When the shutter of the camera is actuated, the terminals of S_3 are short-circuited and the same condition is created as the pressing of the switch S_2. A flash occurs simultaneous to the opening of the camera shutter.

The flashgun described here works on 4 penlight dry cells, or 220 AC mains. One renewal of the cells is sufficient for about 40 exposures. It is a miniature model meant for amateurs (see *B*, Fig. 1). A similar model is available in which a chargeable battery is provided with a self-contained charger. The battery, when exhausted, can be charged by connecting the gun to the mains overnight. One such charge gives about 50 exposures. Bigger guns, which work on the same principle except that their size and, consequently, their light output and range is greater, are also available. They are more suitable for professional work. One such gun is shown in Fig. 1 in two parts — *a* and *b*, *a* to be mounted on the camera and *b* to be held by a shoulder-strap *S*. The chargeable battery arrangement may appear more attractive, but since good leakproof chargeable batteries are not available indigenously, the dry cell system is preferable for amateurs. A flashgun similar to the one shown as *B* in Fig. 1 is available for about Rs. 300. Bigger models cost from Rs. 500 to Rs. 700.

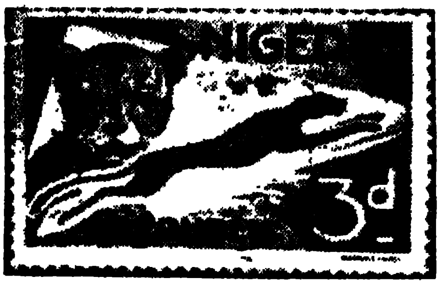
E. U. Siddiqi

Points to remember:

1. **Take care that dry cells are not left in the gun for a long time. Remove the cells when the gun is not being used.**
2. **Store the gun in a cool dry place; moisture is very harmful.**
3. **While fitting the dry cells, polarity should not be reversed. This would permanently damage the transistor.**
4. **Switch S_1 should not be kept in the battery-operation position for a long time. If you do not require an immediate exposure, flick the switch S_1 to the mains-operation position.**
5. **If the neon lamp does not light up even after one minute of switching-on, it means the cells are exhausted.**
6. **The wiring of the flashgun should not be opened or tampered with. A flashgun working on dry cells can give a fatal electric shock as the voltage developed in the circuit is very high.**

SCIENCE ON STAMPS

Rupin Patel



CHEETAH: Carnivore of family Felidae, order *Acinony jubatus*. The large, long-legged hunting cat habituates the open grasslands and deserts of Africa and Asia (up to India).

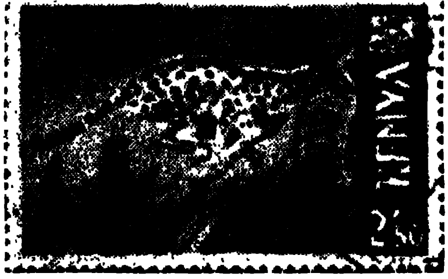
The cheetah is the only one in the family that has only slightly retractable claws. It has a sandy, yellow-brown body with black spots. The spots are smaller and merge better with ground colour than those of the leopard. Its body and head length is about 1 metre and the tail is normally 0·7 m. It is one of the fastest animals, attaining speeds of 104 to 112 kmph over a short stretch. Its height is about 0·7 m and it weighs up to 45 kg.

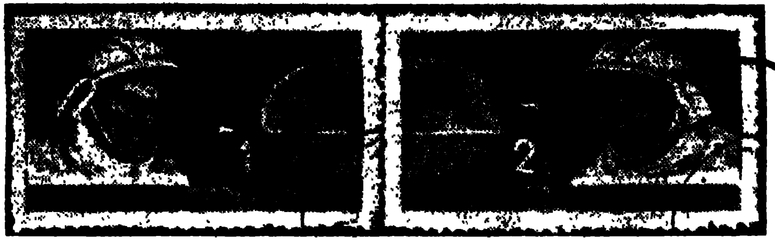
It hunts alone or in a small party by stalking its prey. Litters range from 2 to 4, but cheetahs generally do not breed in captivity.

It is the most dog-like member of the family Felidae and is easily tamed. In Asia, it was often used for hunting antelopes. The name cheetah comes from the Indian *chhita* which means spotted.

3d Nigerian stamp (above). Issued in 1965 as part of a definitive series. Bright green, yellow and dull brown colours.

2sh 50c Kenyan stamp (below). Issued on 12 December 1966. Olive, bistre, yellow and black colours.





SPACE

1s Bulgarian stamp. Colour blue, slate green and black. Depicting Major Andrian G. Nikolayev.

2s Bulgarian stamp. Colour blue green, green and black. Depicting Lt. Col. Pavel R. Popovich.

Both these stamps (above) were issued on 9 December 1962 to commemorate the first Russian group flight of Vostoks III and IV.

5 + 5c US stamp. Multi-coloured.

Both these stamps (below) were issued on 29 September 1967 as a space accomplishment issue.

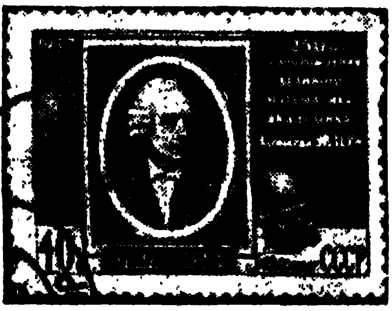
LEONHARD EULER: Swiss mathematician and physicist, was born on 14 April 1707. His importance lies in that he developed into the most prolific writer on mathematical subjects of all times. His writings extend over a wide range of subjects with material covering essentially the whole field of pure and applied mathematics. His main contributions were in the fields of analysis, geometry, algebra, hydrodynamics, astronomy and optics.

Though of Swiss origin, much of his life was spent in Russia at the St. Petersburg Academy. For some years, by invitation and command of Frederick the Great, he was associated with the Berlin Academy also.

He died in St. Petersburg on 7 September 1783. Fourteen years prior to his death, he had become blind. Nonetheless, the last years of his life were very fruitful.

To honour him, Switzerland issued a charity stamp of 5c + 5c on 30 November 1957 in brown caramel colour.

40 k Russian stamp (below). Lilac and gray colour. Issued on 17 April 1957 to commemorate the 250th birth anniversary of Euler.

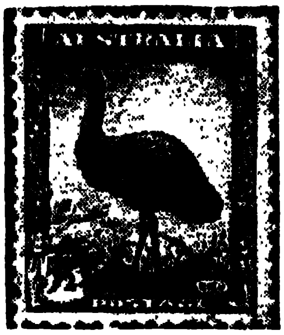


● ●

EMU: A rarite bird of Australia — *Dromiceius novae-hollandiae*. It is allied to the ostrich and next to it is the largest living bird.

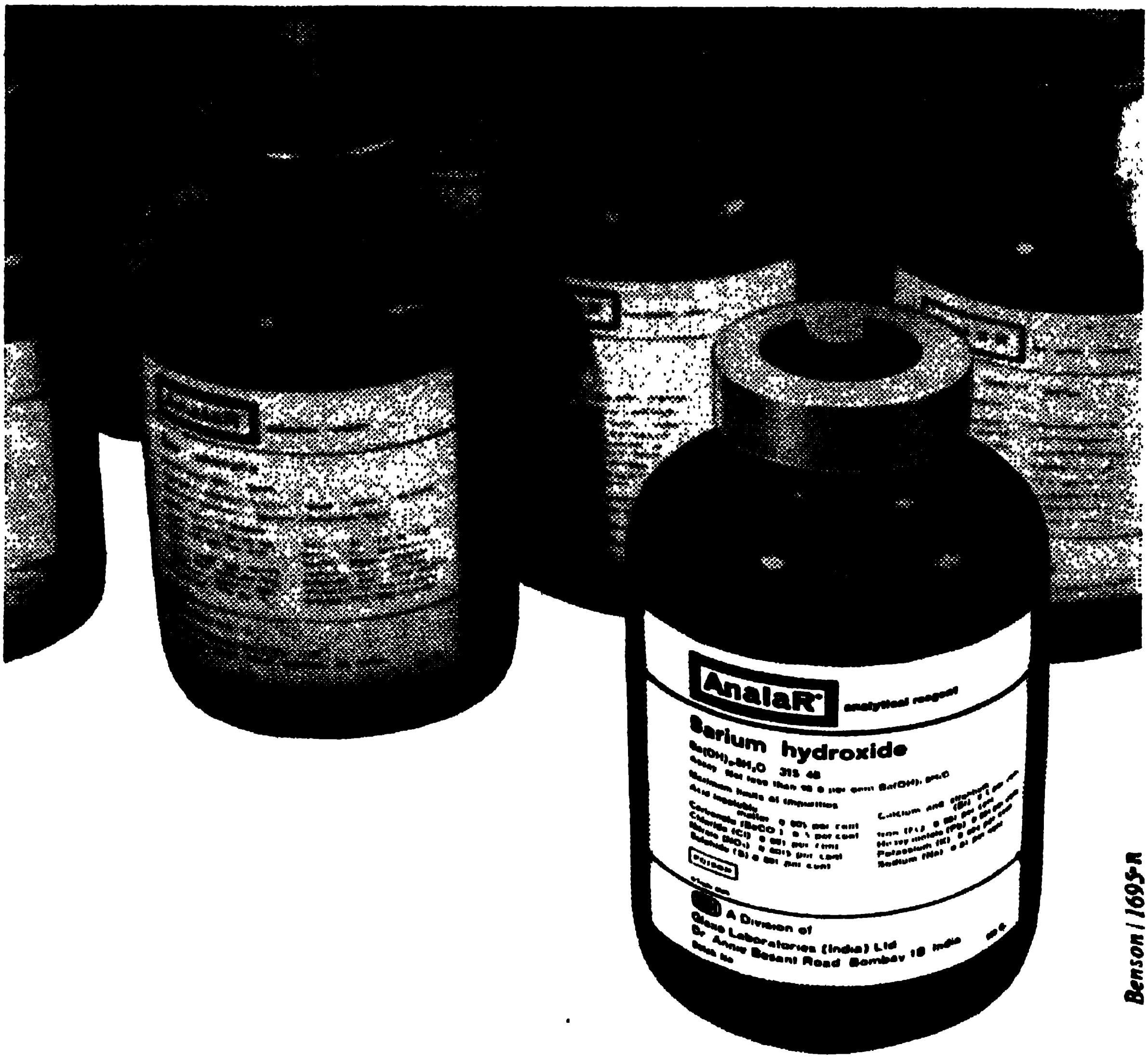
It has rudimentary wings, but powerful legs for running. The neck is fully feathered — the plumage comprising long and slender soft brown feathers. The aftershaft of each feather is as long as the main shaft. There are no horny adornments on top of the head and the small claw of the first toe is missing.

Small groups frequent savannas and open grasslands. They feed on fruits, roots and herbage. During the breeding season, loud booming notes mark their presence. The nest is a shallow pit, scraped in the ground, in which 9 to 13 blue-green eggs are laid. The eggs are so large that incubation lasts for 70 to 80 days. Curiously, the incubation is by the cock, who drives the hen away. The young are striped longitudinally with dark markings on a light background.



Three subspecies are recognised, the fourth being extinct. Due to indiscriminate hunting, the bird is now scarce.

5½ d Australian stamp (above). Indigo colour. Issued between 1942 and 1944 as part of a definitive series.


AnalaR
analytical reagent
Barium hydroxide
A Division of
Glaxo Laboratories (India) Ltd
Dr Annie Besant Road Bombay 18 India

Benson/1695R

now even better...

'AnalaR' guaranteed analytical reagents

'AnalaR' standards have long been established internationally as a guarantee of purity for laboratory chemicals comparable with any other recognised standard. Now they're even better!

To meet the exacting demands of modern laboratory practice, specifications for 'AnalaR' have been made more stringent and extensive. Many additional tests have been included in the light of manufacturing experience and advances in analytical chemistry.

Details of the new standards covering the complete range of 308 reagents are contained in the new edition of 'AnalaR' Standards for Laboratory Chemicals, available from BDH, Bombay.

BDH Laboratory Chemicals Division

Glaxo Laboratories (India) Ltd Dr. Annie Besant Road, Bombay-18 WB

beco

SHAKTI LATHE

The Beco Shakti is the largest, all geared head lathe manufactured in the country. Its high precision and dynamic, torsional rigidity make it ideally suitable for heavy duty production and maintenance work.

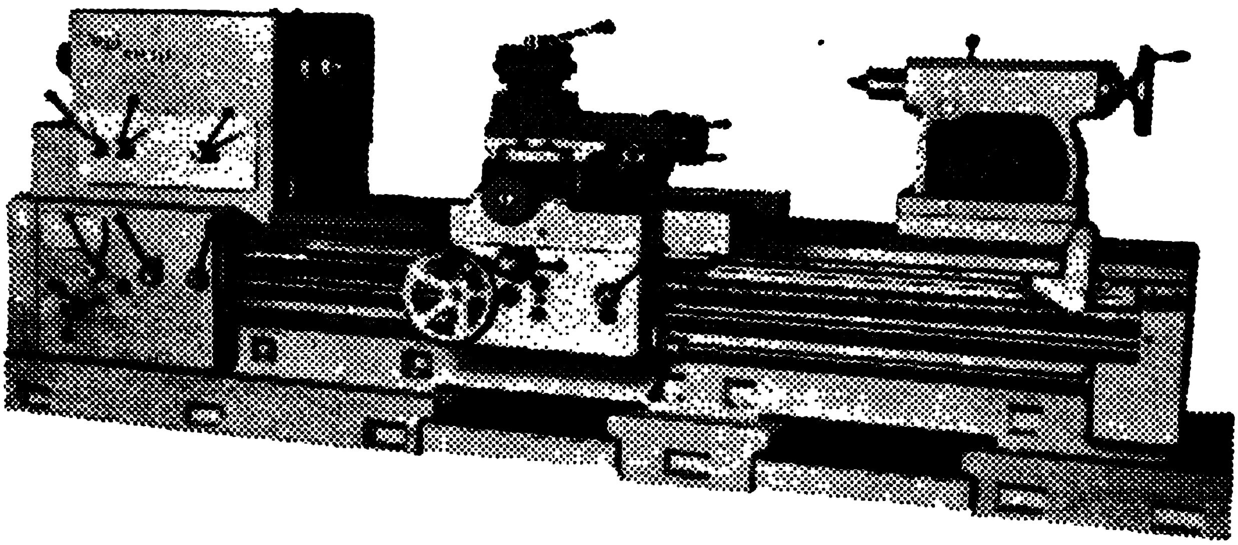
Special features:

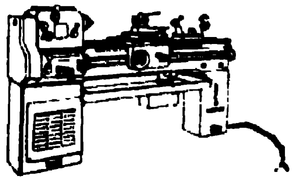
Special design, balanced pressure, lubrication system for the main spindle bearing ensures vibration-free operation under the heaviest loading conditions.

Extra wide, ground bed ways ensures precision and rigidity.

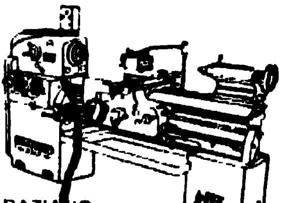
All headstock gears are hardened and force lubricated.

Third shaft with operative levers near Norton and apron allows instant control along full length of bed.

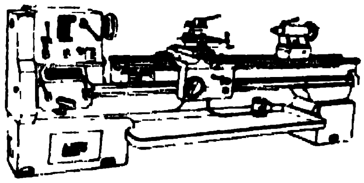




BECO MASTER
Versatile, ideal for production/job shops and technical training-units
Swing 280—315—355 mm



BECO GRAZIANO
High speed high precision high production lathe
Swing 362 mm



BECO VJ
Rigid and sturdy Ideal for heavy production and maintenance shops
Swing 400—450—500—560—630 mm

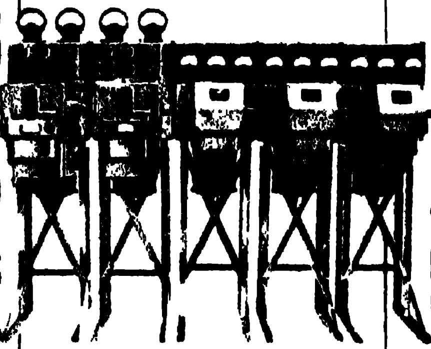
Distributors:
OLTAS LTD.
ACHINE TOOL DIVISION
, GRAHAM ROAD, BOMBAY 1

BECO ENGINEERING CO. LTD.
G. T. Road, Ballabgarh, Haryana, India

oday April 1971

Regd. No. MH 1368

EXCLUSIVE FEATURES OF *MEI* SWITCHGEAR MAKE ELECTRICAL OPERATION SAFEST EVER!



Built-in features in the ASTA tested oil circuit breakers in isolated enclosures, mistake-proof inter-locking and flexible design make MEI L.T. Switchgear the safest control system for industrial power circuits, large motors and sub-stations.

B rawout and non-drawout types are available and the smaller rating breakers can be mounted in double-tier formation where space is limited.

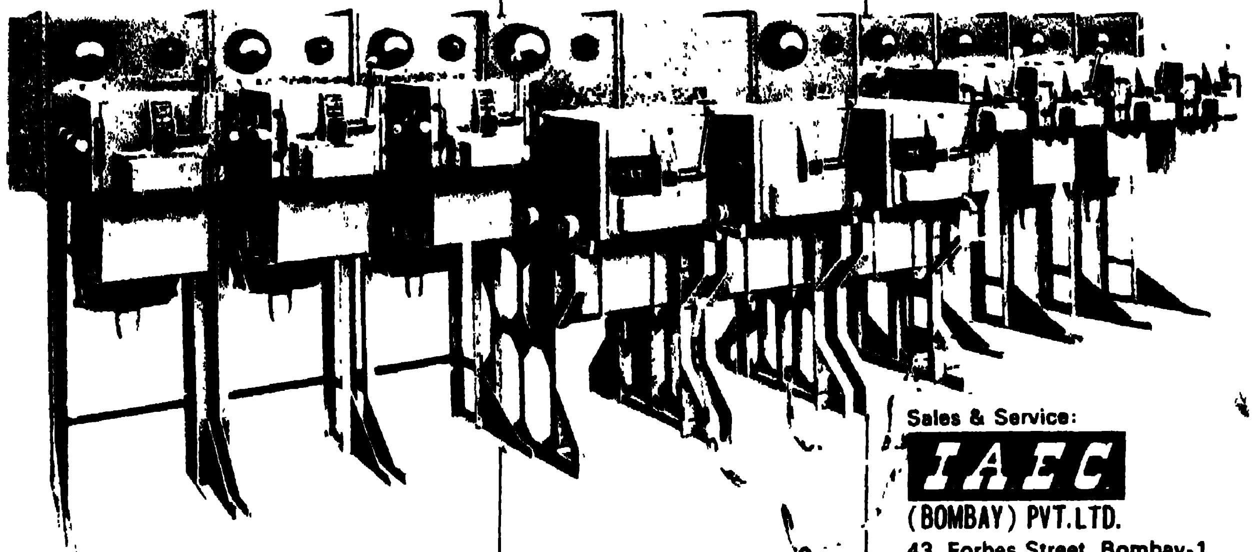
Manufactured by:

THE MYSORE ELECTRICAL INDUSTRIES LTD.

Bangalore.

MEI®

safest for everything in electric power control



Sales & Service:

IAEC

(BOMBAY) PVT.LTD.

43, Forbes Street, Bombay-1

Branch 'K' Block, Chawdhary Bldg., Connaught Circus, New Delhi-1.

Associated offices. Calcutta, Bangalore, Madras, Hyderabad

B Dattaram-MEI-121